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PROCEEDINGS

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ROYAL PHYSICAL SOCIETY.

SESSION CXIII.

Wednesday, 21st November 1883.—Ramsay H. Traquair, Esq., M.D., President, in the Chair.

Archibald Geikie, Esq., F.R.S., Director General of the Geological Survey of Great Britain and Ireland, delivered the following opening address:

In his investigation of the history of the successive revolutions through which the terrestrial areas of the earth's surface have passed, the geologist places his chief reliance upon the remains of plants and animals imbedded in the rocks. The distribution of land and sea at different ancient periods, the growth and isolation or connection of continents and islands, the position of long-vanished lakes and rivers, the vicissitudes of climate in past time—these and other geographical changes depend in large measure for their evidence upon the testimony of organic remains. In the reasoning by which the accepted conclusions in these matters have been reached, there lies as a fundamental postulate the assumption that the laws which now govern the biological domain, have been operative from the beginning. While fossil forms, on the whole, depart more and more from living forms as we trace them into more ancient rocks, yet were we transported into the Jurassic, or Carboniferous, or

Silurian period, though every plant and animal would be new to us, we should find nothing in the structure or development of the organisms at variance with the recognised principles on which the living world of to-day has been constructed.

To the study of fossil organisms a distinctive name—Palæontology—has been given, as if it were a separate and independent science. The term is undoubtedly a convenient one, but its adoption has been in certain respects unfortunate, inasmuch as it has tended to foster an impression that there is some essential difference between living and extinct forms of life. The palæontologist, however, can make no satisfactory progress in his special field of research, except in so far as he is equipped with a knowledge of existing organisms. This may seem a truism, yet it has not always been the principle on which palæontological work has been carried on. But if an acquaintance with the structure, habits, and growth of living plants and animals is essential for the proper understanding of the biological relations of extinct forms, not less imperative is the necessity that all geological speculations, based wholly or partly upon the evidence of fossil organisms, should proceed upon the fullest attainable information regarding the part played by the representatives of these organisms at the present day. We need to study the sources of their food, their peculiarities of habitat, their geographical distribution with the causes that affect it, their conditions of environment, the influences that favour or retard their vigorous growth, their relations to the flora and fauna of which they form a part, how their remains may be imbedded in modern deposits, and whether these remains ever accumulate in sufficient mass to take a noteworthy place among the rock-forming materials of the globe.

I cannot but think that one of the most pregnant results of the deep-sea researches of recent years, is the large treasure of fresh information that has been obtained for the solution of such questions as these. Both the positive data, which have been gathered in such abundance, and the negative data, which are hardly less suggestive, furnish a mass of evidence for geological investigation, and place us in

a far more advantageous position than was enjoyed by our predecessors in the discussion of these problems. It is impossible to refrain from re-examining long-established beliefs in the light of this newer knowledge, and as impossible to resist the changes of opinion to which such a review must inevitably lead.

Among the important contributions from recent deep-sea research towards an enlargement and readjustment of the philosophy of geology, I shall briefly mention a few of the more prominent, and devote the main part of this address to a detailed exposition of one of these.

1. It has now been conclusively established that the deposits which are gathering over the floor of the wider and deeper parts of the ocean, have no counterpart whatever among the sedimentary rocks visible on the land. Various inferences may legitimately be drawn from this fact, but that to which it most obviously and directly leads is, that the land has never lain beneath the deeper and wider parts of the ocean. Yet we have only to turn to many familiar geological writings to see how wide-spread has been the belief that land and sea have been constantly changing places, and that some of the sedimentary rocks that form the dry land were accumulated in abysmal depths of the sea. Had this belief been well founded, it is incredible that nowhere on the land should any trace of such deposits be found, as have been discovered to spread over the floor of the deep sea. I have elsewhere tried to show how strongly this evidence supports the view of the aboriginal character of the oceanic and terrestrial areas of the globe.[1]

2. A second branch of investigation of momentous significance in geological speculation is the determination of the range of temperature in the ocean, and the distribution of submarine climates. The fact, now brought to light, that the great body of the ocean water is cold, and that in the deeper abysses, even at the equator, the temperature sinks towards and even below the freezing-point of fresh water, casts a totally new light on the question of the distribution

[1] Jour. Roy. Geog. Soc., 1879; also Geological Essays at Home and Abroad, 1882, p. 312.

and migrations of marine floras and faunas. In the slow continuous creep of icy polar water towards the equator, and the drift of warmer surface-water towards the poles, the system of oceanic circulation presents itself under a wholly unexpected aspect to the geologist. Moreover, he is taught that, where the configuration of the bottom permits, an arctic and a temperate fauna may co-exist at the same depth, and within a mile or two of each other, kept apart by a narrow interposed ridge that separates the cold from the warmer water.[1] The mere announcement of such facts as these is suggestive of fruitful applications in geology. But we must await the patient elaboration and final publication of their results by the naturalists, who have so skilfully planned and so brilliantly accomplished their observations, before we are in a position to comprehend the full geological significance of the discoveries.

3. A third fact of fundamental consequence recently revealed to us is the prodigious abundance of life in the surface-waters of tropical ocean-currents. I shall have more to say on this subject in the sequel. I may in the meantime remark, that the fact is important because the profusion of pelagic life implies a copious supply of food to higher forms, and consequently an abnormally abundant fauna in the track of the currents. Food is thus shown to be a far more efficient cause in determining the development of life than some of the more recondite influences which are often invoked.[2] From the analogy of the existing sea-bottom we may infer that ancient wide-spread limestones, composed of crinoids, corals, foraminifera, mollusks, and other organisms, were not formed in closed seas, but rather in areas of no great depth, across which currents could bring an abundant supply of food from the main ocean. Viewed from this side, such a formation as the Carboniferous Limestone acquires a fresh interest. The thick calcareous mass that stretches from the west of Ireland into Westphalia, instead of marking the site of a supposed

[1] See Mr Murray's Paper on the Wyville Thomson ridge (Proc. Roy. Soc., Edinb., 1882, vol. xi., p. 638).

[2] See A. Agassiz (Trans. American Academy, 1883, vol. xi.).

Palæozoic Mediterranean Sea, may rather afford some indication of the direction in which a current from the warm south-west flowed eastward over what is now the centre of Europe.

4. A fourth contribution to geology, from recent investigations into the zoology of the sea, relates to the manner in which coral-reefs have been formed. I shall endeavour to show, by a detailed statement of this case, how deep is the debt that geologists owe to the naturalists of those great exploring expeditions which have been so marked a feature in the scientific research of the last decade.

So much additional information has in recent years been obtained regarding the physical and biological conditions of the sea, that such a problem as that presented by the coral-islands of mid-ocean may well be reconsidered. Several able naturalists have lately called attention to this problem, and have insisted that the generally-received solution of it is not satisfactory. Among geologists, there may not unreasonably be a good deal of unwillingness to admit that this contention can be well founded. They have long been accustomed to regard Darwin's theory of coral-formation with justifiable pride, as a masterpiece of exhaustive observation and brilliant generalisation. It has played an important part in their speculations regarding the larger movements of the earth's crust, and they have been so deeply impressed with its simplicity, and the grandeur of the conclusions to which it leads, that they will naturally and rightly refuse to surrender any portion of it save under the strongest compulsion of evidence. Some, indeed, may be inclined even to resent, almost with the warmth inspired by a personal injury, any attempt to show that it can no longer claim the general applicability which has been regarded as one of the strongest arguments in its favour. But the example of Darwin's own candour and over-mastering love of truth remains to assure us that no one would have welcomed fresh discoveries more heartily than he, even should they lead to the setting aside of some of his own work. I propose to give here, somewhat in detail, the more important data accumulated in recent years on this subject, and to state the conclusions to which a

careful consideration of the evidence seems to me inevitably to lead.

Before the memorable voyage of the "Beagle," the generally-received opinion regarding the origin of the circular coral-reefs or atolls of mid-ocean was, that they had grown up on the rims of submerged volcanic craters. The enormous size of some of the atolls—thirty miles in diameter—might have been thought a sufficiently formidable objection to this explanation. But it did not appear insuperable, even to so cautious a philosopher as Lyell, who only noticed it to refer his readers to the great dimensions reached by truncated volcanic cones, which, he thought, might retain their forms more easily under a deep sea than on land.[1]

An earlier and better theory, as Darwin admitted, had been started by Chamisso, who supposed that the circular form of an atoll was due to the fact that, as the more massive kinds of coral thrive most vigorously in the play of the surf they naturally keep to the outside of the reef, and raise that portion to the surface first. But when Darwin's own views were published, first in abstract before the Geological Society in 1837, and subsequently more fully in his separate volume on the structure and distribution of coral-reefs, in 1842, they were soon generally accepted, and were regarded not only as affording a satisfactory explanation of the whole phenomena, but as comprising one of the most impressive generalisations with which Geology, fertile in such achievements, had yet astonished the world.

The theory proposed by Darwin, now so familiar, connected all the types of reef together as stages of one long process, every step in which could be illustrated by actual examples. At the one end stood the Fringing-reefs, some of which might only lately have been started upon a recently-upraised sea-bottom. Out of this stage, by continuous or intermittent subsidence, came Barrier-reefs. Then, as the depression went on, and the islands encircled by the barrier-reefs disappeared, their sites were taken by Atolls. Lastly, where the rate of subsidence was too rapid for the upward growth of the corals, an atoll might become a submerged

[1] Principles of Geology, 4th edit. (1835), vol. iii., p. 310.

bank. Not only was this explanation self-consistent, but it harmonised well with the conclusion, derived from totally different evidence, that there may have been wide-spread and long-continued subsidence over the ocean-basins. It was, moreover, supported by the independent testimony of competent observers, who, with at least equal opportunities of studying the subject, had espoused Darwin's views. Of these witnesses, the most important was undoubtedly Professor Dana, who accompanied the Wilkes' Exploring Expedition of 1838-42.[1] Another powerful ally was found in Mr Couthouy, who had studied coral-growths in the Pacific and in the West Indian Seas.[2] But even without the concurrent testimony of eye-witnesses, the theory proposed by Darwin fitted so admirably into the geological theory of the day that it came itself to be used as one of the most cogent proofs of vast oceanic depression. And such is still the position which it holds.

By a gradually widening circle of observations, however, a series of facts has been established, which were either not known, or only partially known, to Darwin. It should be borne in mind that, compared with more recent explorers, he did not enjoy large opportunities of investigating coral-reefs. So far as can be judged from his published works, he appears to have examined only one atoll—the Keeling Reef; and one barrier-reef—that of Tahiti. The Admiralty charts, the work of previous voyagers, and unpublished information communicated to him, enabled him to extend his generalisation over the whole of the rest of the coral regions which he had not personally explored. The deep-sea expeditions of recent years have now brought so much new light to bear upon the whole question, that we are in a far better position to discuss it than he was nearly half a century ago. Of a few of the more important investigations, a brief *resumé* may here be given, and their bearing upon Darwin's theory of coral-reefs will then be discussed.

As far back as the year 1851, the late L. Agassiz stated

[1] The narrative, containing Professor Dana's observations on Coral-Reefs, appeared among the Reports of the Expedition. In 1872 he published a volume on Coral and Coral-Reefs, where he again gave the weight of his authority to the theory of subsidence.

[2] Boston Jour. Nat. Hist., iv., 1843-44, p. 137.

that, in his opinion, the theory of subsidence could not be applied in the explanation of the Florida reefs; that, on the contrary, the southern end of Florida is built up on successive contentric barrier-reefs, which have been gradually connected and cemented into continuous dry land by the accumulation and consolidation of mud-flats between them, and that this process is still going on, and must eventually convert the present keys and reefs from Cape Florida to the Tortugas into similar land.[1]

In 1863, Professor Carl Semper published the results of his researches among the Pelew Islands. He found himself unable, by the theory of subsidence, to account for the phenomena there presented, and threw doubts upon the general applicability of that theory. He pointed out that, while the southern islands, probably once atolls, consist of coral rock upraised to from 400 to 500 feet above the sea, and are flanked by living coast reefs, true living atolls exist at the northern end of the group. He contended that there is absolutely no evidence of subsidence; that the association of all the different kinds of reef within so circumscribed an area seems entirely to disprove the notion of subsidence; and that, at least in this group of islands, Darwin's theory cannot be applied. In some suggestive observations on their probable origin, he remarks that the reefs depend mainly, for their form, upon the nature of the bottom on which they begin. Atolls spring up on submarine banks. A species of *Porites* takes root in little colonies, varying from the size of the fist to masses six or eight feet in diameter. In time the central portions of these growing colonies die, while the outer parts flourish and gradually build up a ring of coral. This ring, which may be circular or elongated in form, is sometimes continuous, but more commonly is traversed by one or more channels. The interior portions are scoured out and deepened by the tidal currents; or, if the form of the bottom and other conditions be suitable, a great many individual masses of coral gradually grow into a more or less continuous

[1] Bull. Mus. Comp. Zool., vol. i. See also J. Le Conte, Proc. Amer. Assoc., X., 1856, part ii., p. 103; and E. B. Hunt, Silliman's Journal, xxxv., 1863, p. 388.

reef, through which the strong ebb and flow of the tide serve to keep open some channels. Thus, fringing-reefs, through the scour of the sea, become barrier-reefs, which retreat from the adjacent coast in proportion to the gentleness of the slope on which they are built. On a steeply-shelving sea-bottom the reefs must, obviously, remain fringing-reefs.

Dr Semper admitted that possibly many atolls and barrier-reefs were formed during subsidence, and even that the downward movement may, in many cases, have furnished the conditions for starting them into existence. The solution of the problem ought in each case, he thought, to be determined by actual detailed observations. But that the alternate currents of the tides are the main agents in the building of coral reefs could be proved, he maintained, by many cases, which, on the theory of subsidence, must be regarded as exceptional or inexplicable, such as the occurrence of true atolls in the midst of areas of elevation.[1]

In the second edition of his "Coral Islands," published in 1874, Darwin briefly referred to Semper's observations. He thought it not improbable that the Pelew Islands originally subsided, were afterwards upraised, and again subsided; but admitted that the proximity of fringing-reefs was opposed to his views. He suggested that, if the submarine slope were steep, reefs which began as fringing-reefs would continue to be of that form, even during subsidence. There is, however, no admission that any valid objection had been made to his theory, or that true atolls and barrier-reefs might be formed in many places without subsidence.

In 1868 Professor Semper reiterated his dissent from the prevailing theory of coral-reefs.[2] Next year he reprinted his original paper (which seemed to him to have remained unknown to most naturalists) in a general account of the Philippine Islands,[3] wherein he appended some additional

[1] Zeitsch. Wissensch. Zoologie, 1863, xiii., p. 558. Reprinted in 1869 in "Die Philippinen und ihre Bewohner," with additional notes.

[2] Verhandl. Physik-med. Gesellsch., Würzburg: Sitzungber., 1st February 1868.

[3] Die Philippinen und ihre Bewohner, Würzburg, 1869, pp. 100-109. A brief account of the coral-reefs of the Philippine Islands will be found at pp. 19-33.

notes. In one of these he refers to the observations of Pourtales and others on a submarine calcareous deposit, which, in some regions, is slowly being upraised to serve as a foundation for coral-reefs. To the objection that if atolls and barrier-reefs could be formed during a period of elevation they ought to be found not merely at, or only slightly above, sea-level, he replies that they are not, in fact, confined to that limited zone, but that, even if they were, this would not invalidate his conclusion that the reefs are due to a complex co-operation of coral growth with the waves and currents of the sea, and not to the one cause—the subsidence of entire regions—invoked by Darwin.

In the following year another contribution to the anti-subsidence literature was made by Dr J. J. Rein, who, in an interesting memoir on the physical geography of Bermuda, offered some observations on the coral-reefs of these islands.[1] He suggested that the Bermuda group might originally have been a submarine mountain or bank, on which colonies of corals, mollusks, echinoderms, and other organisms took root, flourishing in such abundance as gradually to raise the top of the submerged ground to the zone in which reef-building corals could begin. He adduced no evidence in support of this suggestive forecast, further than that there is no proof in Bermuda of subsidence, which, however, as Darwin had so cogently shown, from the very fact of the movement being downward, is, in most cases, not to be looked for.

An important memoir, marking a totally new departure in coral-reef literature, appeared in 1880, containing an abstract of observations made by Mr Murray during the great voyage of the "Challenger."[2] The chief features of this contribution may be thus briefly summarised. With hardly an exception, the oceanic islands are of volcanic origin, and it is therefore to be presumed that the submarine ridges and peaks, which rise to within various distances from the surface, are likewise due to the protrusion of volcanic materials. There is thus no actual evidence of the still

[1] Bericht. Senckenberg, Naturforsch. Gesellsch., 1869-70, p. 157. See Note, *postea*, p. 30.

[2] Proc. Roy. Soc., Edinb., 1879-80, x., p. 505.

unsubmerged portions of any extensive continent or mass of land such as Darwin's theory requires. Whether built up above the sea-level into islands, or brought up to varying heights below that level, the volcanic eminences of the ocean may conceivably be brought into the condition of platforms for reef-builders by two causes. In the first place, the erosive force of waves and tidal scour must tend to reduce all prominent oceanic summits to the lower limit of breaker action, and thereby to produce truncated cones or flattened domes and ridges, on which coral-reefs, if not already established, might spring up. In the second place, submarine eminences may have been brought up to within the zone of the reef-builders by the deposit of organic *detritus* upon them. One of the most remarkable results of recent deep-sea explorations has been the accumulated evidence of the extraordinary profusion of pelagic life in the tropical surface waters. From experiments made during the cruise of the "Challenger," Mr Murray estimates that, if the organisms are as numerous down to a depth of a hundred fathoms as they were found to be in the track of the tow-net, there must be more than sixteen tons of carbonate of lime, in the form of calcareous shells, in the uppermost hundred fathoms of every square mile of ocean. The shells and skeletons of these organisms fall in a constant rain to the bottom, where their organic matter supplies food to the fauna which there subsists upon the mud. By the accumulation, partly of these superficial *exuviæ*, partly of the remains of creatures living at the bottom, an organic deposit is growing over the sea-floor in the tropical regions wherein coral-reefs flourish. Owing probably to the greater solvent action of the carbonic acid of sea-water at great depths, or to the greater mass of water through which they must sink, the shells of the upper waters seem never to reach the abysmal bottom, or, at least, soon disappear from it, for they are seldom met with in deep dredgings. But in the shallower portions of the ocean they abound; consequently it may be legitimately inferred that the rate of growth of the calcareous organic deposit on the sea-bottom must be more rapid in the shallower waters. The tops of submarine peaks and banks, being constantly

heightened from this cause, will, in course of time, be brought up to a depth at which sponges, hydroids, deep-sea corals, annelids, alcyonarians, mollusks, polyzoa, echinoderms, and other organisms can flourish abundantly. When this has taken place, the upward growth of the calcareous formation will be accelerated by the accumulation of the remains of this abundant fauna as it lives and dies on the bottom. At last, the zone of reef-building corals will be reached, and thereafter a growth of coral rock will bring the sea-floor up to the level of low-water. That coral-reefs, undistinguishable from barrier-reefs and even atolls, might be formed upon banks of sediment in a deep sea, was admitted by Darwin.[1] But the assumption of so many submerged banks as this explanation would require, seemed to him so improbable that he dismissed it from further consideration. He was not aware, however, of the enormous abundance of minute calcareous organisms in the surface-waters, and of the comparative rapidity with which their remains might be accumulated on the sea-bottom.

Reef-builders, starting on a submarine bank, whether prepared for them by erosion, by subsidence, or by the upward growth of organic deposits, would form reefs that must necessarily tend to assume the atoll form. The central portion of the colony or clump of coral will gradually be placed at a disadvantage, as compared with the peripheral parts of the mass, in being further removed from the food supply, and will consequently dwindle and die. In proportion as the reef approaches the sea-level, these central parts are brought into increasingly uncongenial conditions, until at last an outer ring of vigorous growing coral-reef encircles an inside lagoon overlying the central stunted and dead portions. The possibility of such a sequence of events was likewise recognised by Darwin. "If a bank, either of rock or of hardened sediment," he says, "lay a few fathoms submerged, the simple growth of the coral, without the aid of subsidence, would produce a structure scarcely to be distinguished from a true atoll."[2]

[1] Coral Islands, 2d edit., p. 118.

[2] *Op. cit.*, p. 134.

As the atoll increases in size, the lagoon becomes proportionately larger, partly from its water being less supplied with pelagic food, and therefore less favourable to the growth of the more massive kinds of coral, partly from the injurious effects of calcareous sediment upon coral growth there, and partly also from the solvent action of the carbonic acid of the sea-water upon the dead coral. This process of solution of dead calcareous organisms by sea-water is undoubtedly one of the most interesting facts in the chemistry of the ocean which has been brought to light by the naturalists of the "Challenger" Expedition.

Moreover, a connected chain of atolls might be formed on a long submarine bank, and similar conditions of growth would then be displayed, as in the case of the single atoll. The marginal atolls, having a better supply of food, would grow more vigorously than those towards the centre, and would tend to assume elongated forms, according to the shape of the bank beneath them. Many of them might coalesce, and might even ultimately give rise to one large atoll. Such a chain of atolls as that of the great Maldive group may be thus explained without the necessity for any disseverment by oceanic currents, as Darwin supposed. On the other hand, the submerged coral banks of the Lakadive, Caroline, and Chagos Archipelagos may be regarded as representing various stages in the growth of coral-reefs; some of them being still too deep for reef-builders, others with coral-reefs which have not yet quite grown up to the surface. But scattered among these banks are some of the most completely formed atolls. Mr Murray contends that it is difficult to conceive how such banks can have been due to subsidence, when their situation with respect to each other and to the perfect atolls is considered. He reverses the order of growth as given by Darwin, who cited the great Chagos bank as probably an example of an atoll which had been carried down by a subsidence more rapid than the rate at which the corals could build upwards.

From a careful study of barrier-reefs, Mr Murray concludes that in their case also, all the phenomena can be explained without having recourse to subsidence. He found, from per-

sonal observation and a comparison of the Admiralty charts, that most exaggerated notions prevail regarding the depth of water immediately outside the reef, which is usually supposed to be very great. After minutely exploring the barrier-reef of Tahiti, and sounding the water both inside and outside the reef, he found that the slopes are just such as might be looked for, on the supposition that the corals have grown up without any sinking of the bottom. The accompanying section (Fig. 1), drawn on a true scale, will show that there is nothing abnormal in the declivities. Beginning near the shore, or wherever the bottom, whether of rock or sediment, comes within the range of the reef-builders, a barrier-reef grows vigorously along its outer face, while its inner parts, as in the case of an atoll, and for the same reason, are enfeebled and die. The force of the breakers tears off huge masses, sometimes 20 or 30 feet long, from the face of the reef, especially where, from the borings of mollusks, sponges, etc., the coral-rock has been weakened. These blocks tumble down the seaward face of the reef, forming a remarkably steep talus. It is this precipitous part of the reef which has probably given rise to the notion that the water outside suddenly descends to a profound depth. The steep front of fallen blocks is succeeded by a declivity covered with coral-sand, beyond which the bottom slopes away at an angle of no more than 6°, and is covered chiefly with volcanic *detritus.* Mr Murray insists that any seaward extension of the reef must be on the summit of the talus of broken coral. The reef will gradually recede from the shore of the island or continent, and will leave behind, here and there, a remnant to form an island in the slowly-broadening lagoon channel.

The very general occurrence of proofs of elevation among the regions of barrier-reefs and atolls is in harmony with the volcanic origin of the ground on which these coral formations have grown, but, as Mr Murray contends, is most difficult of explanation on the theory of subsidence. He affirms that all the chief features of coral-reefs and islands not only do not necessarily demand the hypothesis of subsidence, but even in areas where the movement is an upward one, may be satisfactorily accounted for by the vigorous outward growth

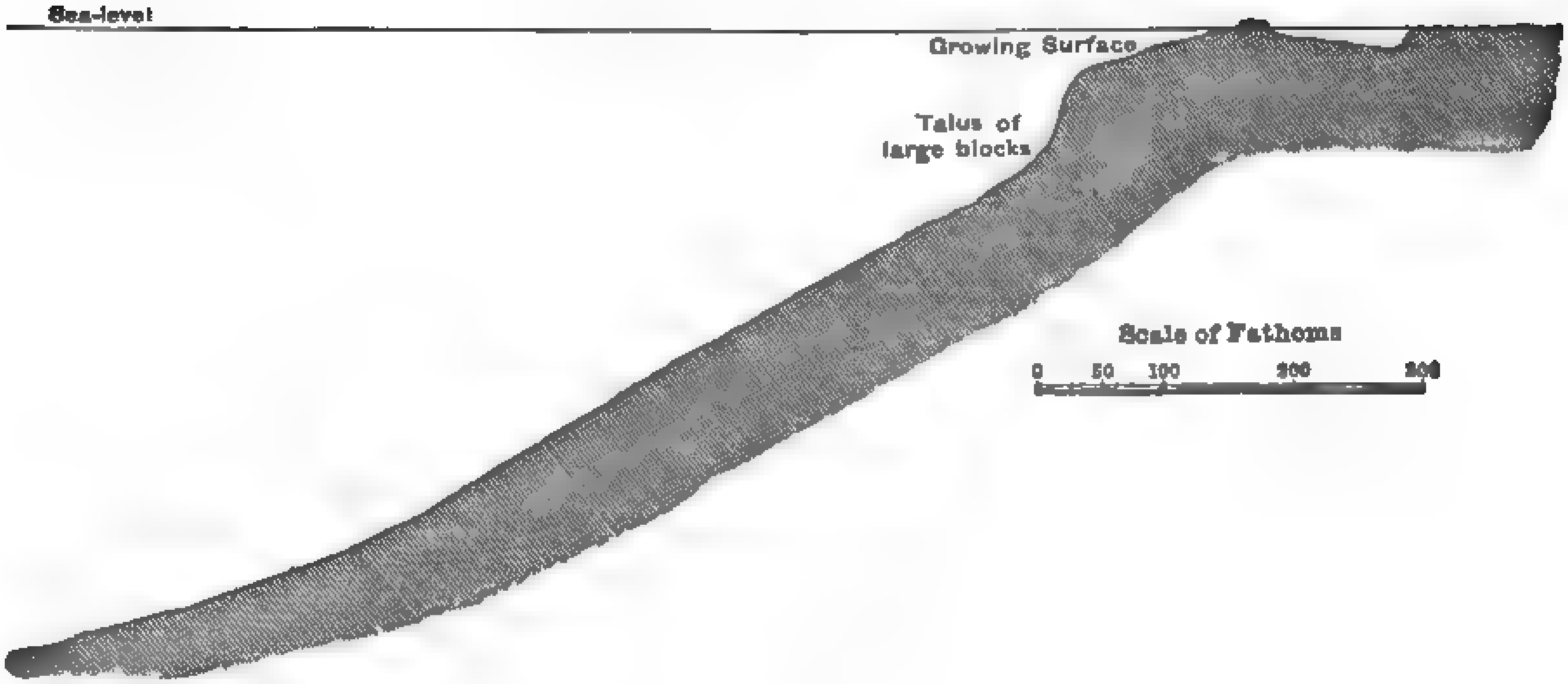

Fig. 1. Section of the Barrier-Reef of Tahiti on a true scale, vertical and horizontal, from a joint survey by Mr Murray and Lieut. Swire, R.N., during the voyage of the "Challenger."

of the corals on the external faces of the reef, in presence of abundant food; by their death, disintegration, and removal by the mechanical and chemical action of the sea in the inner parts; and by the influence of subaërial agencies and breaker-action, in lowering the level of the upraised areas of coral-rock.

The most detailed investigation of coral-reefs which has yet appeared, has recently been published by Professor A. Agassiz.[1] This able naturalist is engaged in prosecuting a series of researches into the biological phenomena of the seas on the eastern side of the United States, under the auspices of the United States Coast Survey, and in the course of these explorations, has had occasion to devote himself to the detailed study of the coral-reefs of the Florida seas. For purposes of comparison, he has likewise visited the reefs among the West Indian Islands, as well as those on the coast of Central America. His observations are thus the most exhaustive and methodical which have yet been published, and the deliberate conclusions to which he has come deserve the most attentive consideration. He traces the history of a coral-reef from its latest stages as dry land to its earliest beginnings, and even beyond these, to the gradual evolution of the conditions requisite for the first starting of the reef. His familiarity with the nature of the bottom all over the area in question, and with the life so abundant in the tropical waters, gives him a peculiar advantage in this inquiry. The upheaval of recent coral-formations to considerable heights above the sea, in various parts of the region, enabled him to examine the inner structure and foundations of the reefs, and to obtain therefrom altogether new data for the solution of the problem. Following him in his induction, we are led back to a comparatively recent geological period, when the site of the peninsula of Florida was gradually upraised into a long swell or ridge, having its axis in a general north and south direction, sinking gently towards the south, but prolonged under the sea as a submarine ridge. The date of this elevation is approximately fixed by the fact that the Vicksburg limestone was upraised by it, and this limestone is assigned to the upper Eocene series. As a consequence of

[1] On the Tortugas and Florida Reefs (Trans. Amer. Acad., xi., 1883).

the elevation, a portion of the sea-bottom was brought well up into the waters of the Gulf Stream, which were probably shifted a little eastward.

No marine fauna yet explored equals in variety of forms or number of individuals that which peoples the waters of the Caribbean Sea and the Gulf of Mexico, from a depth of 250 to about 1000 fathoms. This prolific life is traced by Professor Agassiz to the copious food-supply carried by the warm tropical currents, combined with the food borne outwards from the seaboard of the continent. The corresponding abundant fauna found by the "Challenger" in the Japanese current may be regarded as its counterpart in the Pacific Ocean. Professor Agassiz points also to the diminished richness of the fauna on the western sides of the continents as being probably connected with the absence of those warm equatorial currents which bring such an abundant supply of food to the eastern shores. "No one," he remarks, "who has not dredged near the hundred-fathom line on the west coast of the great Florida plateau can form any idea of the amount of animal life which can be sustained upon a small area, under suitable conditions of existence. It was no uncommon thing for us to bring up in the trawl or dredge large fragments of the modern limestone, now in process of formation, consisting of the dead carcases of the very species now living on the top of this recent limestone." Mollusks, echinoderms, corals, alcyonoids, annelides, crustacea, and the like, flourish in incredible abundance on the great submarine banks and plateau, and cover them with a growing sheet of limestone, which spreads over many thousands of square miles, and may be hundreds of feet in thickness. In these comparatively shallow waters, and with such a prodigiously prolific fauna, which supplies constant additions to the calcareous deposit, the solvent action of the carbonic acid upon the dead calcareous organisms is no doubt reduced to a minimum, so that the growth of the limestone is probably more rapid than on almost any other portion of the sea-bottom.

From the charts we learn how extensively submarine banks are developed in the West Indian region, in the track

of the warm currents. East of the Mosquito coast in Central America, one of these banks may be said to stretch completely across to Jamaica. Similar banks rise off the Yucatan coast; likewise on the windward side of the islands, where the ocean-currents first reach them.

That these banks lie upon volcanic ridges and peaks can hardly be doubted; though we have no means of telling what depth of recent limestone may have accumulated upon them. Among the islands recent volcanic masses rise high above sea-level, in Martinique reaching a height of more than 4000 feet. And, as usual in volcanic regions, there are numerous proofs of recent upheaval, such as the Basse Terre of Guadaloupe, the successive terraces of recent limestone in Barbadoes, and the upraised coral-reefs of Cuba, which lie at a height of 1100 feet above sea-level.

The West Indian seas have long been famous for their coral-reefs. Professor Agassiz insists that the distribution of these reefs is determined by the direction of the food-bearing ocean currents. They flourish on the windward side of the islands and along the whole eastern coast of Honduras, Venezuela, and Yucatan; but on the leeward shores they do not exist at all. Cuba is fringed both on the north and south side with reefs; but the southern reefs, directly bathed by the Gulf Stream and exposed to the prevailing winds, are more flourishing than the northern reefs, which are, to some extent, cut off from the equatorial current by banks and islands.

The depth at which corals will flourish in these seas has been found to be rather less than that which has been ascertained to be in general their downward limit. Professor Agassiz concludes that they do not thrive below a depth of six or seven fathoms in the Florida seas, though on the outer reef, directly exposed to the open currents and prevalent winds, they descend in scattered heads to about ten fathoms.

Each successive stage in the growth of an atoll seems to be laid open for study in the prolongation of the Florida Reefs. The map of that region (Fig. 2) shows a remarkable broken chain of islets and strips of land, running parallel with the

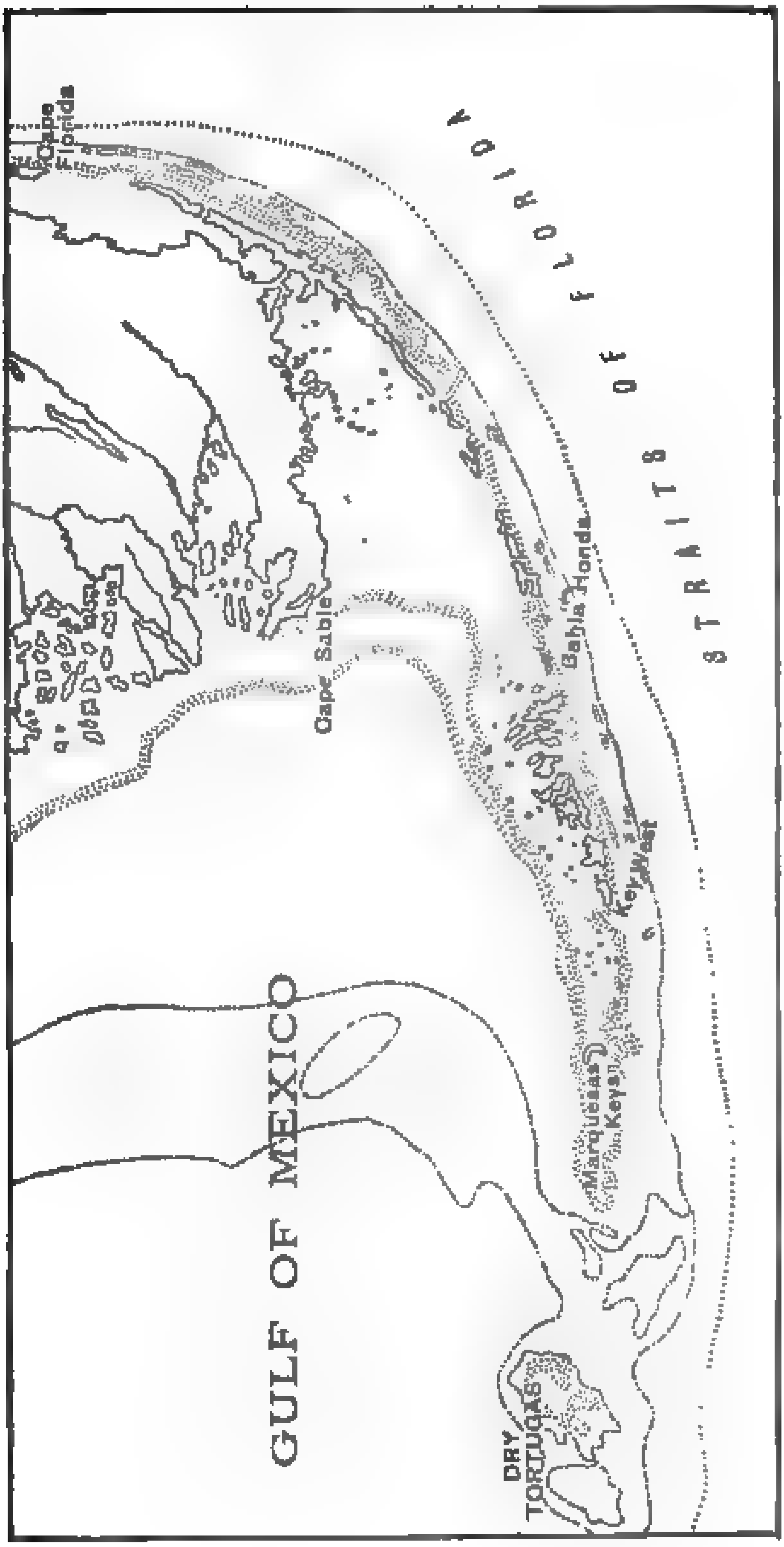

Fig. 2. Map of the Florida Reef and Keys (from Prof. Agassiz' "Memoir").

coast, first in a southerly direction, but gradually curving round until it takes a due westerly trend. This westward curve is attributed mainly to the influence of the strong counter-current, which, with a width of 10 to 20 miles, sweeps westward into the Gulf of Mexico along the left side of the Gulf Stream, and heaps up organic *débris* in its track. Florida is growing westward in the line of this current. Reef after reef is added to the land at the east end; while, towards the west, new reefs successively begin on the bank as its surface is gradually built up by the accumulation of organic *débris.*

The last and youngest of the reefs marked on the maps and charts is the group known as the Tortugas. But immediately to the west of this group Professor Agassiz has found a prominence on the submarine bank, on which corals have begun to grow. Large heads of astræans and madrepores have fixed themselves at a depth of from six to seven fathoms, and *Gorgoniæ* are found a little lower. This is the beginning of an atoll. The Tortugas, which present a further stage of development, consist of an elliptical, atoll-shaped reef, in three chief parts, whereof the largest forms a crescent, fronting to the east, round the edge of the submarine bank, while the two other portions have grown south-westwards along the bank. Three channels between these portions allow powerful tidal currents to rush across the central, chiefly submerged, parts of the atoll. Seven islands have been formed on the higher parts of the reef by the accumulation and induration of calcareous *débris* tossed up on the reef by the waves. To the breakers and currents, combined with the distribution and habits of growth of the reef-builders, Professor Agassiz entirely attributes the form and growth of the reef. The most important corals are the madrepores, which flourish in extensive patches, two common species of *Porites,* occurring in clusters over the shallow tracts of coarse sand, and *Mœandrina areolata,* growing between the marine lawns of *Thalassia,* with occasional patches of *Anadyomene.* Immense masses of nullipores and corallines grow on the tops of the dead branches of the madrepores, which have been killed by exposure to the air during extreme low tides,

or when strong winds have blown the water off the flats. Large heads of astræans and *Mœandrina* occur here and there towards the edge of the reef, which is occupied mainly by clusters of *Gorgoniæ.* The destruction of the reefs by the waves is very great, the sea being occasionally discoloured with the chalky sediment to a distance of from 6 to 10 miles after a storm. Broken coral-heads and branches, dead corallines, shells of mollusks, old serpulæ tubes, stalks of *Gorgoniæ*, and other organisms, are thrown up into lines that consolidate into a low dyke, which in turn is pounded up and removed by the breakers. A prodigious quantity of calcareous sediment is thus produced, much of which is swept into the interior of the reef, where it accumulates in flats of sand and silt. It is only at the outer edge of the reef, where the scour of the sea is greatest, that the corals can flourish: elsewhere they are choked and buried under the deposit of calcareous sediment. Some of this sediment accumulates in steep submarine banks, like sand-dunes, which shift to and fro as winds and currents vary; though, by the action of the carbonic acid of the sea-water, they are apt to be cemented into solid slopes, some of which have an angle of as much as 33°. So great is the destructive and transporting influence of the sea, under the combined or antagonistic working of tides, currents, and wind-waves, that the whole mass of the reef, as well as the flats and shoals inside, may be said to be in more or less active movement. Hence none of the landmarks furnished by the islands are to be relied upon for the location of buoys.

A still more perfect example of an atoll formed under similar conditions is that of Alacran, on the opposite coast of Yucatan. Its eastern face is a great arc of about twenty miles, where, exposed to the open sea and the easterly winds, the corals flourish vigorously. On the eastern, or interior, face of the western chord of the reef, however, the silt derived from the pounding of the breakers to the eastward has already killed the corals. The lagoon is occupied by detached coral-heads, with lanes of clear water between them.[1]

To the east of the Tortugas, near the mainland of Florida,

[1] Bulletin Mus. Comp. Zool., v., No. 1.

older stages of development among coral-reefs may be traced. By the westward drift of the calcareous sand and silt, the lagoons have been converted into flats, and these in succession have been turned into more or less continuous dry land. There is no evidence of subsidence. The area seems to have remained stationary for a long period, or, if there has been movement at all, it has been in an upward direction. Should the present condition of things be prolonged, there will be a further extension of the Florida coast-line. By the heaping-up of the shells of dead organisms in the track of the counter-current, the submarine bank will continue to be brought up within the depth at which reef-building corals can grow. Successive clumps of reef-builders, springing up and growing outward, will build atoll-shaped reefs. The abrading action of the waves upon these reefs will furnish *detritus* to be drifted into the lagoons and channels, which will eventually be silted up into dry land.

An interesting indication of the progress of these changes is furnished by the terrestial fauna and flora of the Florida reefs. The plants of the mainland are found likewise on the reefs, but become fewer in number as they are followed southward, until, on the Tortugas—the last addition to dry land—the flora consists of a few bay-cedars, a hop-vine with a thick white flower, Bermuda-grass, and a solitary mangrove tree. One of the species of land-shell common at Key-West has found its way to the Tortugas. No terrestial reptiles have yet reached that furthest atoll, though at Key-West, less than 100 statute miles to the east, many of the frogs, toads, lizards, and snakes, common to the southern mainland, have already established themselves.

It will be observed that the conclusions arrived at by Professor Agassiz, from his own independent researches, entirely confirm those previously announced by Mr Murray. That two observers, who have enjoyed exceptional advantages in the investigation of this subject, should come to practical agreement, must be admitted to be a strong argument in favour of the views which they have adopted.

Putting together all the data which have here been summarised, I think we are driven to admit that barrier-reefs

and atolls may be formed without subsidence of the sea-floor. Whether this has been the usual, or only an exceptional, manner of their origin, is a question that will depend for its solution upon whether or not it can be shown that there are general phenomena which can only be explained by subsidence. Three such phenomena may be adduced. I am not aware of any others that deserve serious consideration.

1. One of the early difficulties which Darwin's explanation appeared satisfactorily to solve, was the necessity for the existence of so many peaks coming up from the depths of ocean just to the zone in which reef-building corals live. No cause was conceivable which could have so generally arrested the upward growth or upheaval of these submarine heights at the limit where coral-reefs might begin. And this difficulty has always been looked upon as furnishing one of the strongest arguments in favour of the theory of subsidence, for that theory removes it, by showing how, in a general submergence, peak after peak would sink and come within the sphere of the operation of the reef-builders.

The difficulty is met in a totally different way by those who believe it to be more formidable in appearance than in reality. They contend that, while it must not be forgotten that many peaks do rise above the sea-level, and many submarine banks still fall far short of reaching up to the coral-zone, two powerful causes conspire to bring submarine banks to a common uniformity of level at a short distance below the surface of the ocean. On the one hand, those portions of volcanic mountains that rise above the sea-level are worn down by the atmosphere and the waves, and, unless otherwise preserved, must eventually be reduced to the lower limit of effective wave-action, which is probably nearly coincident with the lower limit of reef-builders. On the other hand, submarine banks in tropical seas are built up towards the surface by the accumulation of the aggregated remains of plants and animals which live on the bottom, or fall down to it from upper waters, and the magnitude of this upward growth is hardly yet adequately realised.

In balancing these opposite views we must, I think, admit

that subsidence is adequate to provide platforms for coral-reefs, but that these platforms could likewise be furnished by the two other processes just referred to. Subsidence has been invoked because no other solution of the problem seemed admissible. But as another solution has been found, the argument in favour of subsidence has no longer the same force. The new solution, being based upon facts which are everywhere observable in the coral regions, appears to me to be more probable than the older one, which is only an inference resting on no positive proofs.

2. The precipitous descent of the outer face of the reefs to depths far below those at which corals can live, is another difficulty which finds a ready explanation on the theory of subsidence. If it were true, as is popularly assumed, that a coral-reef presents towards the ocean a vast perpendicular wall of limestone, entirely composed of solid coral, there could be no escape from the conclusion that subsidence must have occurred to permit of such an aggregation of coral-rock. We learn, however, that much misconception exists on this subject. Some of the earlier accounts of the coral islands speak of "unfathomable" depths at a short distance seawards from the reefs; but more recent soundings afford no confirmation of these statements. Instead of being the summits of vast submarine pillars of limestone, atolls, as well as barrier-reefs, appear to be really planted on the tops of submarine peaks and ridges. The outer face of the reef itself is undoubtedly steep, in some places vertical. At Tahiti, for example, as shown in Fig. 1, the living face of coral may extend to a depth of 30 to 35 fathoms, beneath which huge detached blocks of coral are piled up and cemented together, forming a steep face which descends to about 150 fathoms at a distance of 180 fathoms from the outer edge of the reef. The sea-bottom beyond that point is covered with coral-sand, and slopes at 25° to 30°, after which the angle lessens to 6°. By the abrading action of the breakers in tearing off blocks of coral, and strewing them down in steep talus-slopes, a platform is prepared on which the actually growing part of the reef can build outwards.

In Darwin's section of the Gambier Islands, the thickness

of the encircling reef is made to be about 2000 feet.[1] Professor Dana by one estimate puts it at 1150, and by another at 1750, feet. He assumes that in general the thickness of solid coral must be considerable, though he admits that calculations based on the seaward continuation of the slope of the land are liable to error from many causes.[2] Even if we admit (what cannot be proved) that the calcareous mass of any coral-reef does attain a thickness of many hundred feet, it would not necessarily consist wholly of solid coral.[3] Professor Agassiz has followed the growth of a reef on a platform of calcareous organic *detritus*, and he has found elevated coral-reefs which rest on such a platform. Mr Murray's observations explain how a reef may grow outward on a talus of its own *débris*. There appears to be no reason, indeed, why a calcareous mass of almost indefinite thickness might not be formed without the aid of subsidence. Its upper zone might be directly due to coral growth, while the larger part of the mass would be composed of an aggregate of coral *débris*, mixed with the remains of mollusks, echinoderms, and other calcareous organisms. So rapid is the destruction of organic structure, through the solution and redeposit of carbonate of lime by infiltrating water, that a special and careful search might be required to determine the actual limits of the true reef and of its calcareous platform, and even such a search might not be successful.[4]

After a full consideration of this second difficulty, I feel compelled to admit that no valid argument in favour of sub-

[1] Coral-Reefs, 2d edit., p. 65.

[2] Corals and Coral Islands, 2d English edit., 1875, p. 126.

[3] Professor Dana cites examples of raised coral-reefs 250 to 300 feet above sea-level; but we do not yet know how much of the rock is solid coral, and how much may be formed of aggregated organic *débris*.

[[4] Since this Address was read, and the chief portion of it appeared in *Nature* (Nov. 29 and Dec. 6, 1883), an interesting letter by Dr Guppy announces that he has found elevated coral-reefs at heights of 100 to 1100 or 1200 feet among the Solomon Islands; that the coral-rock itself forms a comparatively thin crust, and is underlaid by a mass of impure earthy limestone, abounding in foraminifera and other pelagic organisms, such as pteropods (*Nature*, 3d Jan. 1884). This is precisely the structure that the observations of Mr Murray and Professor Agassiz would lead us to expect.—*Note added 12th January* 1884.]

sidence can be based on the steepness of the seaward face of a reef and the thickness of the calcareous mass of the reef itself.

3. The depth of some lagoons and lagoon-channels furnishes probably the strongest argument in favour of Darwin's views. Occasionally a depth of forty fathoms is reached, and as this is beyond the depth at which reef-builders ordinarily live, it has been regarded as a proof that subsidence has taken place.

This third difficulty is thus met by the opponents of subsidence. We must remember, they say, that from the very conditions of their growth, patches of coral tend to assume an annular or atoll-like form, because the outer parts grow vigorously, while the central portions eventually die. Where the coral patches coalesce, and extend along a bank or shore, it is their outer or seaward faces that flourish. The inner parts, as they are more and more cut off from the food supply, gradually die. While the outer face of the reef grows seawards, the inner margin is attacked, partly by the solvent action of the carbonic acid of sea-water, partly by wind-waves, and the tidal-scour sweeps away much fine *detritus* through gaps in the reef. In this way, the lagoon-channel is widened and deepened. In a perfect atoll—that is, an unbroken annular reef of coral—the lagoon could not be deepened by any mere abrasion of the dead coral and removal of the *detritus* in suspension, but solution by carbonic acid would still come into play. It is further to be borne in mind that small lagoons are shallow, and are being filled up, and that it is only the large ones, encircled by nearly continuous reefs, where the corals in the lagoon and along its margin are dead, and where the effects of solution may be conceived to have been longest in operation, that the depth of the lagoon descends below the limits at which reef-builders live.

I do not regard this solution of the difficulty as wholly satisfactory. Of the fact that dead calcareous organisms are attacked and carried away in solution in sea-water, there cannot be any question, and this process must be of great geological importance. Whether the solvent action is sufficient to account for the exceptional depth of some lagoons is still, I think, open to inquiry. It seems to me not im-

probable that these comparatively few deep lagoons may owe their depth partly to subsidence. But if this be the case, it would lend, I am afraid, but slender support to a theory of wide oceanic depression. That there must be some areas of subsidence over the coral regions is almost certain, and the few scattered deep lagoons may possibly indicate some of these areas.

Having thus fully examined the arguments on both sides of this interesting and important question, I feel myself reluctantly compelled to admit that Darwin's theory can no longer be accepted as a complete solution of the problem of coral-reefs. No one could be more impressed than myself with the simplicity of this theory, the brilliancy of its generalisation, its remarkable fitness in geological theory, and the grandeur of the conceptions of geographical revolution to which it leads. I am fully alive to the serious changes which its abandonment will make in some departments of geological speculation. But in the face of the evidence which has now been accumulated, I can no longer regard the accepted theory as generally applicable. That it may possibly be true in some instances may readily be granted. There may be areas of subsidence, as there certainly are areas of elevation, over the vast regions where coral-reefs occur. It may be conceded that subsidence may sometimes have provided the platform whereon coral-reefs have sprung up, and may have contributed to heighten some reefs and to deepen some lagoons and lagoon-channels. But I do not believe that we are now justified in assuming subsidence to have taken place, from the mere existence of atolls and barrier-reefs. Its occurrence at any locality must be proved by evidence of special local movement. It may have gone on at many localities where atolls and barrier-reefs are found; but the existence of such reefs is no more necessarily dependent upon subsidence than upon elevation. These subterranean movements must be looked upon as mere accidents in a general process of coral-growth, which is wholly independent of them.

I may, in conclusion, refer to one or two difficulties which have long been felt to be serious drawbacks to the theory of subsidence, but which disappear when the newer views of

the origin of coral-reefs are accepted. If, as Darwin supposed, the coral-islands of the Pacific and Indian Oceans represent the last peaks of submerged continents, it is incredible that continental rocks should not be found among them. The oceanic islands (except, of course, those composed of coral-rock) are of volcanic origin, and show none of the granites, schists, and other rocks which might have been looked for on such elevated summits. They have been piled up by the accumulation of lavas and tuffs discharged from the earth's interior, and, where they occur, point to upheaval rather than to subsidence. Again, as Mr Murray has shown, the inorganic deposits of the ocean-floor are composed of volcanic *débris*, with a singular absence of the minerals that constitute the usual crystalline rocks of our continents.[1]

No satisfactory proofs of a general subsidence have been obtained from the region of coral-reefs except from the structure of the reefs themselves, and this is an inference only, which is now disputed. From the nature of the case, indeed, traces of subsidence can hardly be expected. A few examples have been cited, such as the occurrence of trunks of cedar trees in a layer of red soil in Bermuda, lying between the calcareous deposits at a depth of 42 feet below low-water mark. This indicates a recent subsidence of that tract, but it may be merely local, and may be due to the sinking down of the roof of one of the caverns with which the limestone is so abundantly honeycombed. Occasionally, along the margins of lagoons, trees are found at the water-edge, in a position suggestive of subsidence. But the removal of the calcareous rock by solution or wave action might equally account for their condition.

Of elevation in the region of atolls and barrier-reefs there is almost everywhere more or less distinct evidence. Professor Dana has collected the facts which prove that recent elevatory movements of unequal and local extent have occurred in all parts of the ocean.[2]

Upheaval has taken place even in areas where barrier-

[1] Proc. Roy. Soc., Edinb., 1876-77, p. 247; Murray and Renard, Brit. Assoc. Report, 1879, p. 340.

[2] Corals and Coral Islands, 2d edit., p. 284.

reefs and atolls are in vigorous growth. Such an association of upheaval with an assumed general subsidence requires, on the subsidence theory, a cumbrous and entirely hypothetical series of upward and downward movements. These are unnecessary, if we can be convinced that coral-reefs grow up independent of terrestrial movements, which may, in one area, be in an upward, in another, in a downward, direction. From this point of view, the reefs stand up as the result of a complex series of agencies, among which the more important are, on the one hand, the temperature, solvent power, currents, tides, and waves of the sea; and, on the other hand, the amount and direction of the supply of pelagic food, the upbuilding of calcareous deposits to the zone of reef-builders, the vigorous growth of the coral masses on their outer faces, and their death, decay, and the solution of their skeletons in the inner parts of the reefs. All these causes are known and visibly active. Without the co-operation of any other supposed or latent force, they appear to be entirely adequate to the task of building up the present coral-reefs of the oceans.

I fear I have considerably overstepped the limits of time within which this address should have been confined. Let me only, in conclusion, advert to the interesting bearing of our newer information about coral-reefs and modern marine limestones upon the elucidation of the origin of ancient limestones. Every geologist who has worked among the calcareous intercalations of the older palæozoic rocks, is familiar with their frequent strangely lenticular character. A limestone, several hundred feet thick, suddenly dwindles down and disappears in a most inexplicable way. The suggestion of cross-faults cannot be entertained. If, however, we regard such limestones as akin in their mode of growth to modern coral-reefs, whether formed by actual corals or by other reef-builders, we obtain a possible solution of the difficulty. A very successful attempt in this direction has recently been made by my friend M. Dupont, Director of the Geological Survey of Belgium, in reference to the remarkable lenticular masses of limestone in the Devonian system of Belgium.[1]

[1] Bulletin Acad. Royale Belgique, 3d sér., tome ii., 1881, p. 264; Bulletin Mus. Royal Belgique, 1883.

These calcareous bosses, formed of masses of *Stromatopora* and other aggregated organisms, lie among argillaceous and arenaceous strata, which appear to have formed great submarine banks. Their structure is quite explicable on the supposition that they began in one or more scattered clumps upon these banks, and gradually grew up there into atoll-like reefs, as coral-reefs are now doing upon the banks off the Florida coast.

And now it only remains for me to thank you cordially for the honourable position in which your good will placed me two years ago, and for the uniform kindness and forbearance with which my shortcomings in the discharge of the duties of President have been condoned. I wish for this already venerable Society many long years of active usefulness, and I trust that it may continue to be in the future, as it has been in the past—a centre into which the younger blood of generation after generation will flow, and from which the warmth of sympathy and help will cheer and stimulate the early career of many a distinguished naturalist in days to come.

[*Note added January* 1884. — An interesting series of soundings made last autumn, in what was previously believed to be deep water between the Mediterranean Sea and the Canary Islands, has revealed the existence of submarine mountains, rising in some parts to within less than fifty fathoms from the surface, and covered with growing and dead corals. These elevations are almost certainly of volcanic origin. Their tops are now being raised in level by the growth of calcareous organisms upon them. It is interesting to find this corroboration of the views above advocated, from an area of comparatively cold water where reef-building corals do not live. See paper (by Mr J. Y. Buchanan) in *Times*, 7th December 1883.

Professor Rein, whose work on Bermudas is cited on p. 10, has been so good as to call my attention to a later contribution by him to the anti-subsidence literature of coral-reefs. It was published in the *Verhandlungen erst. deutsch. Geographentags*, 1881 (p. 29), and is entitled—"Die Bermudas-Inseln und ihre Korallenriffe, nebst einem Nachtrage gegen

die Darwin'sche Senkungstheorie." In this interesting paper the author emphasises his dissent from the theory of subsidence, and refers to the confirmation of his original suggestion by the deep-sea explorations of recent years. In the appendix he sums up his conclusions, asserting that the assumption of extensive submergence in the coral seas rests on supposition, and not on exact observations, the supposed vast thickness of modern coral-reefs being illusory and unsupported by any measurements; that the association of all the kinds of coral-reef within the same limited area is inexplicable on Darwin's theory; that in no geological formation, from palæozoic up to recent time, are there any coral-reefs approaching the thickness asserted to characterise living reefs, their average depth being much less than 300 metres; that coral-reefs may be simply and naturally explained as the crowning of submarine banks which have been sufficiently heightened by the accumulation of the remains of plants and animals; and that the form of the reefs, especially of the atolls, depends primarily on the shape of the bottom and the food-supply, and is thus more simply and naturally accounted for than by subsidence.]

I. *On the Structure of* Sarcodictyon. By W. A. Herdman, Esq., D.Sc., F.L.S., Professor of Natural History in University College, Liverpool. [Plates I.–III.]

(Read 19th December 1883.)

I. Introductory.

While dredging in Lamlash Bay, Arran, during the summer of 1880, I was fortunate enough to obtain several good living specimens of *Sarcodictyon catenata* (Forbes). They were all small colonies of the usual red colour, and attached to pieces of stone and dead shells. As I was occupied with another group of animals at the time I contented myself with identifying the species, and then preserved them in alcohol for future use.

Last September (1883), while dredging in the neighbour-

hood of Tarbert, Loch Fyne, I again met with *Sarcodictyon* growing over stones and shells, but this time two forms occurred, one red and the other pale yellow. This circumstance induced me to examine the minute structure of the two varieties with the view of determining whether or not there is any essential difference between them, and on returning to Liverpool I examined the specimens dredged at Lamlash in 1880.

All the colonies in my possession appear to belong to one species, *Sarcodictyon catenata* (Forb.). Although this form has been briefly described or referred to by several authors, its anatomy and histology have never, I believe, been thoroughly investigated.

II. Historical.

The species was first discovered and named by Professor Edward Forbes, but I have not been able to find his original description of it, if one was ever published. In Johnstone's "History of British Zoophytes," 2d edition[1] (1847), the generic and specific descriptions of *Sarcodictyon catenata* are given on Forbes' authority, but without any reference to a publication, while the few rough but characteristic figures of the appearance of the colony are stated to be reproductions of Forbes' drawings. From this it seems likely that Forbes did not publish an account of *Sarcodictyon* previous to 1847, but supplied Dr Johnstone with the descriptions and figures found in the "British Zoophytes," 2d edition. In that work, the species is rightly placed amongst the Alcyonaria, and the description and figure are sufficient for identification, but no account of the minute structure is given.

In January and February 1851, Professor Edward Forbes read before the Royal Society of Edinburgh a paper[2] entitled "On some remarkable Marine Invertebrata new to the British Seas," in which he stated, that while on a yachting

[1] The genus *Sarcodictyon* is not mentioned in the 1st edit. (1838), and it is not referred to in Mr William Thompson's "Report on the Fauna of Ireland" (Brit. Assoc. Rep., 1843, p. 245), where all the known British Alcyonaria are given upon Dr George Johnston's authority; consequently Forbes must have discovered it between 1843 and 1847.

[2] Trans. Roy. Soc., Edinb., vol. xx., p. 307, 1853.

cruise among the Hebrides during August 1850 he dredged *Sarcodictyon catenata* and also a second species, *Sarcodictyon agglomerata*, "in 30 fathoms water off Croulin Island, and also between Rasa and Scalpa." In this paper *Sarcodictyon agglomerata* is described as a new species, and a brief account is given of its external appearance, in which it is stated that the colour is "invariably ochraceous yellow," while "the polype cells, instead of being arranged in single file, are grouped together in assemblages of from three to five, each group being connected with its neighbours by a stolon-like extension of the polypidom."

In the previous summer, in his "Report on the Investigation of British Marine Zoology by means of the Dredge," read before the British Association at Edinburgh,[1] Forbes had referred to the two species of *Sarcodictyon* as having been found in the following localities:—*S. catenata*, in 1845, off Armadale, Sound of Skye, 1½ mile from shore, depth, 25 fathoms, bottom, mud and stones; in 1845, at entrance of Sound of Skye, ½ mile from shore, depth, 20 to 30 fathoms, bottom, mud and stones; in 1850, in Aros Bay, Sound of Mull, 1 mile from shore, depth, 25 fathoms, bottom, stones and sand; in 1850, off Croulin Island, ¼ to 1 mile from shore, depth, 25 fathoms, bottom, gravel; also in Clyde district, depth, 20 fathoms, bottom, stones; and in Hebrides, depth, 15 to 20 fathoms, bottom, stones and shells. *S. agglomerata*, in 1850, off Croulin Island, ½ mile from shore, depth, 30 fathoms, bottom, stones and gravel. Hence 1845 appears to be the date of the discovery of *Sarcodictyon catenata*.

In the "Annals and Magazine of Natural History" for 1858,[2] Mr P. H. Gosse has a paper "On *Sarcodictyon catenata* (Forbes)," in which he gives an account of a small colony of the species, which he found on the south coast of England, and succeeded in keeping alive for some time in an aquarium. Some points in his description will be referred to further on.

In December 1867, Pourtales, in the "Contributions to the

[1] Brit. Assoc. Rep., 1850, p. 192, *et seq.*

Ann. and Mag. Nat. Hist., ser. 3, vol. ii., p. 276.

Fauna of the Gulf Stream,"[1] described a new species, *Sarcodictyon rugosum*, as having been found off Havana in 1270 fathoms. His brief diagnosis contains what are probably generic characters only, with the exception of the statement "colour dirty white," consequently it is difficult to say whether or not *S. rugosum* is really distinct from the British species.

In 1870, Mr W. Saville Kent, in a short paper "On two new genera of Alcyonoid Corals taken in the recent Expedition of the Yacht 'Norna' off the coast of Spain and Portugal,"[2] described a new genus, *Gymnosarca*, with one species, *G. bathybius*, found off the coast of Cezimbra, Portugal, at a depth of 500 fathoms. The short generic description seems to be applicable in every detail mentioned to any of the described species of *Sarcodictyon*, so that if really distinct *Gymnosarca* must be a very close ally indeed. The above, with the exception of a passing reference to the structure of *Sarcodictyon* in a paper[3] by Mr Sydney Hickson just published, is the entire literature of the genus, so far as I have been able to ascertain.

In regard to the zoological position of the genus, Milne Edwards and Haime, in their synopsis of the genera of Zoophytes,[4] place *Sarcodictyon* in the family Alcyonidæ, sub-family Cornularinæ. Forbes[5] objects to this, and insists upon its close relationship to *Alcyonium*, from which, he says, "it differs merely in the stoloniferous method of growth." Saville Kent,[6] Claus,[7] and other recent authors, agree in placing *Sarcodictyon* close to *Cornularia* and *Clavularia*, and this seems undoubtedly to be the true position of the genus.[8]

[1] Bull. Mus. Comp. Zool. Harvard Coll., Cambridge, U.S. America, vol. i., No. 6, p. 113.

[2] Quart. Jour. Micro. Science, vol. x., p. 397.

[3] *Ibid.*, vol. xxiii., No. xcii., p. 556, 1883.

[4] Monogr. des Polyp. Foss., Arch. du Mus. d'hist. Nat., t. v., p. 181.

[5] *Loc. cit.*, p. 309.

[6] Quart. Jour. Micro. Science, vol. x., p. 397.

[7] Grundzüge der Zoologie, p. 208, 1876.

[8] Hickson (Proc. Roy. Soc., No. 226, 1883) proposes to unite these genera with *Tubipora* in one group—the Stolonifera.

III. Structural.

A colony of *Sarcodictyon catenata* presents the appearance of a narrow band, the stolon, adhering to the surface of a stone or fragment of shell, and bearing at intervals conical enlargements, the polypes.[1]

The Stolon is flattened from above downwards so as to form a comparatively thin crust closely attached to the stone or shell. It is thickest in the middle of its breadth, and thin at the edges, so that in section its upper surface is convex. Most of the pieces of stolon which I have measured are from 1·5 to 2 mm. in breadth, a few are narrower or broader. In some cases I have found free tips of stolons not connecting polypes, which were tapering and very thin. These were clearly growing points. They were of a paler colour than the rest, being almost colourless in the red variety, and quite colourless in the yellow variety.

In a few cases (see right-hand end of Pl. I., Fig. 1) the stolon is enlarged at its edges to form an expansion of considerable breadth, which may even occasionally (Pl. I., Fig. 2) support several polypes side by side. Hence the polypes are not always placed in a single series. Such a case appears not to have been met with by Mr Hickson, and it seems to supply a link in his chain leading up to an expanded lamellar stolon underlying all the polypes of a colony, as in the case of *Tubipora*.[2] Its bearing upon Forbes' *Sarcodictyon agglomerata* I shall discuss later on.

The stolon expands slightly as it approaches the base of a polype, and is usually narrowest half-way between two polypes. The stolons branch frequently, but always at the base of a polype, a branch never being given off between two polypes. They also anastomose, the points of union being again always at a polype, so that in the networks formed

[1] The colonies I have examined vary in the number of their polypes from 3 to about 150. Gosse (*loc. cit.*, p. 276) speaks of some polypes as being isolated. I have not met with any in that condition. My colonies number as follows:—Yellow variety, Loch Fyne, 12 and 14 polypes; red variety, Loch Fyne, 3, 4, 9, 17, 50, 120, and 150; red variety, Lamlash, 30, 32, 35, 37, 50, 77, and a few others not counted.

[2] Quart. Jour. Micro. Science, vol. xxiii., No. xcii., p. 576, 1883.

(see Pl. I., Fig. 1) a polype is always placed at each angle of the meshes. Of course, in order to form a closed mesh, besides branching, union must have taken place between the growing tips of two stolons, but I have not been able to find traces of this in any of my specimens, and consequently I am unable to say whether the union takes place at the base of a polype or between two polypes.

In one or two cases I found the growing tips of stolons projecting beyond the edges of the stone to which the colony was attached, and one of these had three small polypes on it, thus showing how a colony projecting freely upwards might be developed from an incrusting form.

The Polypes vary somewhat in form, but are always more or less dome-shaped or conical, with the top truncated. In a couple of cases the polypes upon one surface (probably the lower one) of a stone were much lower than those upon the other surface. Fig. 5 on Pl. I. shows the most usual shape of polype in profile view. It rises very considerably above the surface of the stone, even in this contracted condition, and doubtless attains a much greater height when living and expanded.

I did not succeed in getting any of my colonies to expand; but Mr Gosse describes his living polypes as having, when expanded, a height of $\frac{1}{4}$ of an inch, and a diameter of $\frac{1}{16}$ of an inch. The usual size of my retracted specimens is 2 mm. in diameter at the base, and 2 to 2·5 mm. in height; but there are a few polypes which have partially expanded on being placed alive in alcohol, and these show above the body shown in Fig. 5 a colourless zone 1 mm. high and 1 mm. in diameter, and terminating in the mouth opening surrounded by the circle of tentacles, which attain a length of about 2 mm. Hence my partially expanded polype measures, including tentacles, about 5 mm. in height. The examination of such expanded polypes shows that in the contracted specimens the upper part of the body has been entirely retracted, and is not visible externally.

The upper end of the contracted polypes shows a truncated rounded surface with a central aperture (see Pl. I., Fig. 6) surrounded by eight equal-sized and fairly regular lobes.

Fig. 14 in Pl. I. shows a transverse section through the lobes. The grooves between these lobes are in some specimens continued down the side walls of the body, so as to be visible in profile view as lines extending nearly to the base (Pl. I., Fig 5). In a specimen not quite so much contracted as the one shown in Fig. 6, the terminal aperture was wide, the lobes were very regular, and a colourless mass, formed by the upper part of the body bearing the mouth and the tentacles, was visible in the aperture between them (see Pl. I., Fig. 7). Consequently, the terminal aperture in Figs. 5, 6, and 7 is not the mouth opening, but is merely the termination of the non-retractile side walls of the body.

This non-retractile part of the body is, like the stolon, coloured either dull red or pale yellow, according to the variety, but the retractile region above is either much paler and more transparent, or usually quite colourless.[1] It is shown in Pl. I., Fig. 8, which has been constructed by combining portions of two or three partially expanded polypes. Its upper end bears the mouth, surrounded by the eight compound tentacles, which seem to have a slight web uniting their bases, the result being that the body seems in profile view to expand slightly at its upper end.

The tentacles (Pl. I., Figs. 8-11) are not long (2 to 2·5 mm. in length), and are broadest about half-way up. They taper to a rather blunt point at the tip. In one or two cases (see Fig. 11) the tip is bifurcated. Short stumpy pinnæ are borne on the sides of the tentacles; there are from 10 to 20 of these pinnæ upon each side, 14 to 16 are usual numbers. They are largest on the wide central part of the tentacle, and decrease in size towards the base and the tip. There are usually three or four pairs of very short pinnæ at the base of each tentacle (see Fig. 9).

A.—*Anatomy.*

The general anatomy of each polype is of the ordinary Alcyonarian type. The mouth, which is placed on the sum-

[1] In one specimen of the ordinary red variety I noticed that the tentacles and upper part of the body were slightly but distinctly yellow, thus forming an interesting transition to the yellow variety with colourless spicules.

mit of a slight eminence (Pl. I., Fig. 12), leads into the gastric tube or stomodæum, the flattened lumen of which is much encroached upon by thickenings of the walls. This tube opens freely at its lower or aboral end into a body cavity, which is limited by the base below, and by the body walls at the sides, while it is continued above into the cavities of the tentacles. This body cavity is crossed by eight delicate membranes, the mesenteries, which are attached to the outer wall of the gastric tube at equidistant points (which alternate with the tentacles above), and radiate outwards to be attached by their outer edges to the inner surface of the body wall.

Three layers enter into the constitution of the body: 1*st*, the *ectoderm* covers the entire outer surface of the base and body wall, both retractile and non-retractile parts, of the tentacles and their pinnæ, and is continued in at the mouth opening to line the gastric tube in its entire extent; 2*d*, the *endoderm* lines the body cavity throughout, coats both lateral faces of the eight mesenteries and the outer surface of the gastric tube, and lines the inner surfaces of the tentacles; 3*d*, the *mesoderm* lies in all parts of the body between ectoderm and endoderm, consequently it enters into the composition of the body wall, the tentacles, the gastric tube, and the mesenteries. In some places the mesoderm becomes greatly thickened, and in certain regions may develop calcareous spicules in its interior.

In a transverse section through the upper part of the body of a retracted polype, such as is shown in Pl. I., Fig. 16, one finds two concentric rings of tissue united by eight narrow radiating bands (see Pl. I., Fig. 16, *my.*). The outer ring is the non-retractile body wall, formed of an outer layer of ectoderm and an inner layer of endoderm, united by a thick mass of mesoderm. The inner ring is the retractile or invaginated body wall, and is formed by an outer layer of endoderm and an inner layer of ectoderm united by thick mesoderm. The lumen of the tube (*i. t.*) formed by this invagination is flattened from side to side, and then somewhat irregularly pulled out radially towards the points of attachment of the mesenteries which cross the body cavity, and are formed by plates of mesoderm covered on both sides by endoderm,

the result being that the eight inter-mesenteric spaces are lined throughout by endoderm. Each inter-mesenteric space is continued into the cavity of a tentacle.

A transverse section through the body further down, at about the level of the retracted mouth (see Pl. I., Fig. 18), shows externally the body wall, while from its inner surface the eight mesenteries project towards the centre of the section. After running some distance inwards, they become complicated and split into two lateral halves, which join the side walls of the neighbouring tentacles (Pl. I., Fig. 18, *tn.*), seen cut at various angles, and lying retracted in the inter-mesenteric chambers. The open central space in the section is the region immediately above the mouth opening. Fig. 19 on Pl. I. represents a section cut obliquely through the lower end of the invaginated tube, so as to show the passage from the one condition to the other. The upper half of the section shows the invaginated tube and the simple attached mesenteries, while the lower half shows the thickened and complicated mass formed by the retracted tentacles lying in the inter-mesenteric chambers.

A longitudinal section through one of the polypes in a retracted condition shows the body wall turned in at the top of the section, to continue the non-retractile into the retractile portion (Pl. I., Fig. 13). The retractile or invaginated portion (*i. t.*) is found to be folded upon itself, so as to form a sac-like involution on each side of the section. The true mouth opening is shown at *m*, while the lower end of *i. t.* indicates the upper edge of the side wall of the body in the completely expanded condition. The region between the dotted lines from *tn.* is one of the tentacles cut in section; its tip is seen opposite *tn.* From this section it is obvious that, when retracted, the tentacles are received into the inter-mesenteric chambers, and are partially but not completely invaginated, the invagination extending for roughly about half of their length, while the terminal portion lies within the cavity formed by the invaginated portion.

The mouth leads into the gastric tube, which is found in such a longitudinal section to have its walls thrown into a number of strongly-marked horizontal folds, the result being that in a transverse section of such a contracted polype the wall of

the gastric tube may be cut twice or even thrice, instead of once. Such a condition is seen in Fig. 4 on Pl. III., where the wall of the gastric tube appears three times in one part of the section.

In a section lower down, below the gastric tube, the inner ends of the mesenteries are free, but thickened and convoluted, as will be described further on.

B.—*Histology.*

The histology of the different parts of the animal must now be considered in detail. The ectoderm is covered in the non-retractile part of the body wall by a delicate structureless cuticle. Gosse [1] inferred that the integument was of a chitinous nature, from the way in which the dead polype retained its form. The cuticle is clearly visible in most of my sections through the non-retractile portion of the body wall; and I have succeeded in some places in tearing it off, so as to have it in the isolated condition. At first I thought it was confined to this non-retractile part of the body wall, but as I afterwards found a delicate layer visible covering the ectoderm lining the upper part of the invaginated tube, it is probable that it is secreted over the whole surface of the ectoderm, though possibly it is much thicker on the non-retractile body wall than elsewhere. I have not been able to find any trace of it on the tentacles or in the gastric tube. The cuticle appears perfectly structureless, and is of a pale brown colour, staining slightly yellow with picro-carmine.

The ectoderm below the cuticle is formed of a single layer of cells, which in section (see Pl. II., Fig. 8, *ec.*) are elongated and spindle-shaped, with distinct nuclei in the wider central portion. In surface view they are large polygonal squames, with granular contents and distinct centrally-placed nuclei (Pl. II., Fig. 7, *ec.*). They stain light pink with picro-carmine.

The mesoderm of the body wall is a thick layer of tissue, which seems intermediate between a gelatinous and a cartilaginous condition. It consists of an apparently structureless matrix, containing scattered through it small rounded and

[1] *Loc. cit.*, p. 278.

fusiform connective-tissue cells, and penetrated in all directions by a system of branching and anastomosing tubules lined by endoderm cells, and continuous with the body cavity. There are also a large number of spaces in the matrix of the mesoderm, simple lacunæ which lie between the endoderm tubules (see Pl. II., Fig. 16, *lac.*), and are found chiefly in the outer part of the body wall (Pl. III., Fig. 1, *lac.*). Probably these spaces communicate with the tubules.

The mesoderm also contains curiously shaped calcareous spicules, which are rare in the upper parts of the body wall, but abundant in the lower parts and in the stolon, where they form an almost continuous layer, and add greatly to the strength and stiffness of the tissues. These spicules are of a dull red colour, and give to the body wall, and thus to the whole colony, its characteristic hue. In the pale variety, from Loch Fyne, the spicules are colourless, and the slight tint of the colony is due to the soft tissues of the animal.

The spicules vary greatly in shape, sometimes they are rod-like, sometimes branched or forked, and sometimes plate-like, but usually more or less echinated or spinose. I have been able by examining an immense number, a selection from which are represented on Pl. II., to make out that all the different forms are produced by the union of a few simple spicules shaped like a wedge, or more exactly like a quadrilateral terminated by an isosceles triangle. This simple form is shown at Fig. 3 on Pl. II.

In the young growing point of the stolon of a specimen (see Pl. I., Fig. 4) of the yellow variety from Loch Fyne, I found the comparatively simple spicules shown in Figs. 1 and 2 on Pl. II. Fig. 1 shows these spicules in their relative positions, magnified about 50 times. Fig. 2 gives a few of them more highly magnified to show their composition out of simple wedges. *a* is formed of two rods. In *b* the rods are spinose. In *c* they have bifurcated. *d*, *e*, and *f*, are formed of irregular wedges. In *g* three wedges have joined. *h* also shows three wedges with a space for the narrow end of a fourth. In *i* four wedges have united symmetrically. In *j* and *k* they are more irregular. While in *l* they form a cross,

and their lines of junction are almost obliterated. Fig. 6, Pl. II., shows a series of spicules from the growing point of the stolon of the red variety. Here, in addition to forms similar to these described above, there are also to be frequently seen rosettes, formed by the union, more or less regularly, of six wedges.

In Fig. 5 on Pl. II. a mass of spicules from the mesoderm of the body wall is shown. They are drawn in their relative positions, and form as may be seen a dense layer. In the lower part of the body wall they are in some places several layers thick. In most of them the lines indicating the union of wedges have become obliterated, but here and there they can still be traced, and all the various forms found may be reduced to a small number of simple spicules united by their narrow ends, and usually more or less spinose on their surfaces. When more highly magnified these spicules are found to present a minutely dotted or granulated appearance, such as is represented in Fig. 4, Pl. II.

In the upper part of the body wall, the spicules become slighter, less numerous, and paler in colour, and the red colour of the body wall ceases altogether a short distance below the tentacles. Above this, and in the tentacles themselves, spicules are present, but they are slender and perfectly colourless. No spicules are found in the upper three pairs or so of pinnæ and the corresponding portion of the axis of the tentacle. Below this point a few simple rod-like spicules make their appearance (Pl. II., Fig. 10), and as the tentacle is traced downwards, the spicules are found to increase in size and strength, to unite as shown in Figs. 10 and 11, and to form figures like these described from the stolon, but having the branches slighter and more rod-like. One or two very pale red spicules were found in the tentacles, near to the base.

The endoderm of the body wall is a thin layer lining the inner surface of the mesoderm. It is formed of irregular cells mostly somewhat spherical or columnar through mutual pressure, and apparently in some places several layers deep. In some sections many rounded granular cells were found

lying freely in the inter-mesenteric chambers. They appeared to be endoderm cells.

Tubules are given off from the body cavity into the thick mesoderm of the body wall, and these are all lined by endoderm cells continued in from the surface (Pl. III., Fig. 1, *en. cœ.*). The nuclei of these cells form conspicuous dots on the walls of the tubules in sections stained with picro-carmine. These tubules probably open into the lacunæ lying in the mesoderm, and both tubules and lacunæ are continued into the stolons, and thus form a communication between the body cavities of the different polypes of the colony.

In the cavities of the tentacles, the endoderm cells are more regularly cylindrical (Pl. II., Fig. 14, *en.*), and are probably provided with cilia, since Gosse states [1] that he observed ciliary action in the interior of the tentacles in the living polype.

The mesoderm of the tentacles is a thin layer formed almost entirely of muscular fibres (Pl. II., Fig. 14, *mes.*). Most of these fibres run longitudinally, and are clearly visible in a squeezed or teazed-out tentacle under a high magnification (Pl. II., Fig. 13). They run in irregular bundles along the tentacle, and are continued out into the pinnæ, up which they may be traced to the tip. There is also a slightly developed layer of circularly running fibres encircling the tentacle transversely, and placed beneath the longitudinal layer (Pl. II., Fig. 14, *m. f. c.*).

The ectoderm of the tentacles has apparently no cuticle, and the cells are not squamous but more rounded, cubical, or low columnar in form, with distinct nuclei which stain readily in picro-carmine. The surface of the tentacles is not smooth, but is raised up every here and there into low ridges or projections (see Figs. 13 and 14 on Pl. II.). These elevations are due to the ectoderm alone, which in such places is two or three layers deep, and has on its surface between the cells numbers of very small nematocysts and palpocils. I did not find nematocysts in the ectoderm of any other part of the body.

The irregularly stellate lumen of the invaginated tube is

[1] *Loc. cit.*, p. 277.

bounded by ectoderm cells, one row thick in most places, but continued here and there into the subjacent mesoderm in the form of strings of cells several rows deep, and occasionally forming short tubules or cæca. These may branch or join one another, or may be united by strings of ectoderm cells having no lumen (Pl. III., Fig. 6, *ec. cæ.*).

The mesoderm of the wall of the invaginated tube is thick. In some places where it forms the projections into the lumen (see Pl. I., Fig. 16) it is thicker than the mesoderm of the non-retractile part of the body wall. The projections probably correspond to the terminal lobes of Figs. 6 and 7, and the external ridges of Fig. 5. The mesoderm of the invaginated tube is a homogeneous matrix, with a few fusiform connective tissue cells scattered through it. It usually has a considerable number of lacunæ, especially in its inner or ectodermal part, and opposite to the insertion of the mesenteries (Pl. III., Figs. 1 and 5), where the lacunæ extend outwards towards the endodermal surface. This arrangement of lacunæ is just what is to be expected from the fact that the invaginated tube is merely the upper part of the body wall retracted (see Pl. I., Fig. 13). The mesoderm also encloses the ectodermal strings of cells or cæca, given off from the invaginated tube. In its outermost layer, just inside the endoderm, the mesoderm contains a delicate layer of longitudinal muscles (Pl. III., Fig. 1) continuous with those of the mesenteries. Probably these are retractors which aid the muscles of the mesenteries in invaginating this part of the body wall.

The endoderm which forms the outermost layer in the wall of the invaginated tube is exactly like that lining the non-retractile part of the body wall. As a rule it appears to be thickest between the points of insertion of the mesenteries (Pl. III., Fig. 5, *en.*).

Tubules lined by endoderm cells and penetrating into the subjacent mesoderm are found here also, but they are neither so large nor so numerous as the similar tubules in the non-retractile part of the body wall. Whether these endodermal tubules ever communicate, either directly or by means of the lacunæ, with the ectodermal cæca given off from the

inner surface of the invaginated tube I could not determine. Probably there is no communication.

The eight mesenteries appear to be similar in all respects in this part of the body. Each consists of a plate of mesoderm connecting the mesoderm of the invaginated tube with that of the body wall, and covered on both faces by a layer of endoderm continuous with the endoderm lining the body cavity. Superiorly the mesenteries join the upper wall of the body between the tentacles when the polype is fully extended, while below the gastric tube they are continued down in a modified condition to the base of the body cavity.

Throughout the upper part of the mesentery the mesodermal plate is thin (Pl. I., Fig. 16), and homogeneous except on its lateral edge, where there are thin layers of muscular fibres, which appear in transverse sections as rows of small dots (Pl. III., Fig. 1). These muscles are visible on the faces of the mesentery in surface view as strong longitudinal fibres, with a few oblique ones crossing them (Pl. II., Fig. 15, *m. f. l.*).

Lower down, in the portion of the mesentery which joins the gastric tube, the mesoderm is thicker and the musculature stronger. The peculiar plaiting by which a thick bundle of muscle may be formed out of a single layer of fibres, as R. Hertwig[1] has described in the Actiniaria, is here found well developed. The single row of muscle fibres is bent many times backwards and forwards, so as to form a deeply sinuous line in transverse section (Pl. III., Figs. 2 and 3). The homogeneous mesoderm is developed into shorter and longer ridges and projections, so as to support the sinuosities of the muscular layer lying on it. This formation of a branched figure in transverse sections, with pinnæ and sometimes pinnules, is well developed on one face only of each mesentery (Pl. III., Fig. 3), but is sometimes present to a slight extent on the other face. By this anatomical feature one face of a mesentery may be distinguished from the other, and in *Sarcodictyon,* just as in the Actiniaria[2] and the

[1] Zoology of the Voyage of H.M.S. "Challenger," Part xv., Report on the Actiniaria, p. 5.

[2] See Hertwig, *loc. cit.*

Pennatulida,[1] the mesenteries are symmetrically arranged (Pl. I., Fig. 18), the pair at one end of the body having their muscular faces turned towards each other, while those at the opposite end have them turned away.

Further down the body, below the gastric tube, the mesenteries become even more complicated. Their inner free edges, which are continued down from the lower end of the gastric tube are greatly and irregularly thickened, convoluted, and frequently joined together to form the craspeda or mesenterial filaments[2] (Pl. II., Fig. 9). The result is that the edge of the same mesentery may be cut several times in the same section, and thus variously complicated figures are produced. The thickenings which constitute the craspeda are almost entirely due to the growth of the endoderm covering the edge of the mesentery, although the mesoderm is also increased and continued into the branched and convoluted endodermal processes as a homogeneous supporting layer.

The endoderm cells of the mesenteries form a continuous layer throughout, covering both faces and the free inner edge below the gastric tube, and being in direct continuity with the endoderm layer lining the body wall, and that coating the outer surface of the gastric tube. The cells (Pl. III., Fig. 8, *en.*) are rounded, or of short columnar or cubical form usually one layer deep, but in some places an inner very delicate layer of flattened cells is distinctly visible lying between the ordinary endoderm cells and the layer of muscular fibres. These inner cells do not form a continuous layer (Pl. III, Fig. 7, *n. c.*). They are of various shapes—fusiform, triangular, and polygonal, and their angles are continued into delicate fibres which occasionally anastomose. The cells are distinctly but minutely granular, and have large circular nuclei with distinct nucleoli. The whole appearance of the layer suggests that it is nervous, and as such I consider it, but I was unable to make out with certainty the presence of this system under the epithelial layers in other parts of the body.

[1] See Marshall, Report on the Oban Pennatulida, Birmingham, 1882.

[2] From Krukenberg's experiments (Vergleichend physiologische Studien an den Küsten der Adria. 1st Abth. Ueber den Verdauungsmodus der Actinien, 1880), it is most probable that these craspeda are digestive in their function. See also Marshall, *loc. cit.*

The gastric tube which is continued down from the elongated mouth opening (Pl. I., Fig. 12) is flattened so as to be irregularly elliptical in transverse section. At one end of the longer axis are placed the two mesenteries which have their muscular faces turned towards each other, while the two mesenteries at the other end have the corresponding faces turned from each other. Hence the inter-mesenteric chamber at the one end contains two pinnate muscles, and that at the other end contains none (see Pl. I., Fig. 18). The remaining six inter-mesenteric chambers—three on each side—have each one pinnate muscle.

The wall of the gastric tube is thick and is much folded upon itself, both vertically and horizontally (Pl. I., Fig. 13). It is lined by a layer of ectoderm continued through the mouth opening from the ectoderm lining the invaginated tube. Fig. 8 on Pl. III. shows half of the gastric tube in transverse section highly magnified. The ectoderm layer (*ec.*) is seen to be thrown into ridges and grooves, and is formed of long columnar cells closely placed. No cilia were visible in my specimens, although they are probably present in the living condition. The "siphonoglyphe" was not distinct, probably on account of the corrugation of the wall, but I recognised traces of it here and there in a few of the sections, by means of the very long cilia which were still attached to the cells.

Outside this epithelium is a thick layer of mesoderm formed of an inner mass of muscular fibres, and an outer comparatively narrow homogeneous band (*mes.*) which is continuous with the mesoderm of the mesenteries. This outer structureless layer of mesoderm has a narrow line of muscle fibres on its outer side just beneath the endoderm, and these fibres are continuous with the muscles on the sides of the mesenteries.

The endoderm forming the outermost layer of the gastric tube is like the endoderm lining the body wall, and is continuous with the same layer of cells on the faces of the mesenteries (Pl. III., Fig. 8). In such cases as the one represented in Fig. 4 on Pl. III., where the wall of the gastric tube has been cut several times in the same horizontal plane, the different transverse sections are exactly similar, the second and third being merely repetitions of the first or inner one so far as structure is concerned.

Unfortunately none of the polypes which I examined or sectionised contained reproductive organs. I searched most carefully over the free edges of the mesenteries in a number of sections, but was unable to find anything which could be considered as even the young condition of ova or sperm cells. Gosse,[1] in describing his living specimen, talks of a mass at the lower end of the body which he saw through the body walls, as being probably the ovaries on account of its opacity, but possibly it was merely the thickened mass of craspeda which I have described above. It is not even known yet whether or not all the polypes in a colony of *Sarcodictyon* are of one sex as is the case in *Pennatula*,[2] and many other Alcyonaria. I hope to investigate this and a few other undetermined points in fresh material on some future occasion.

IV. Final.

In conclusion, the two forms which I dredged in Loch Fyne, and which I have referred to above as the red and the yellow "varieties," seem to differ in nothing but colour, which is due to the spicules in the one case being of a red tint, while in the other case they are colourless. Hence both forms must be considered as *Sarcodictyon catenata* (Forb.). In *Alcyonium digitatum* in the same way two very distinct colours of colony are found.

I have not seen Forbes' *Sarcodictyon agglomerata*, and can judge of it merely from his figures and the original description in which two points of distinction from *S. catenata* are specified:—(1.) the polypes are not arranged in single file, but are grouped together in assemblages of from 3 to 5, each group being connected with its neighbours by a stolon; and (2.) the colour is "ochraceous yellow." Now, in several of my colonies of the red variety of *Sarcodictyon catenata*, here and there the polypes are not placed in single file, but form small groups united by a continuous basal expansion which gives off the ordinary narrow stolons leading to other polypes or groups of

[1] *Loc. cit.*, p. 278.

[2] See Marshall's Report on the Oban Pennatulida, Birmingham, 1882.

polypes. Such a condition is shown on Pl. I. in Fig 2. and at the right-hand end of Fig. 1; and this seems to unite the first characteristic of Forbes' *Sarcodictyon agglomerata*, with the other features of *S. catenata*. Then the second characteristic of *S. agglomerata* is, of course, seen in my yellow variety of *S. catenata*. Hence, if *Sarcodictyon agglomerata* is really a distinct species from *S. catenata*, it will require to be carefully examined and redescribed; and I have shown above that Pourtales' *S. rugosum* is insufficiently characterised, and does not seem from the published description to differ from the British species. Consequently there is, so far as I am aware, only one well-marked species of *Sarcodictyon* known to science.

Explanation of the Plates.

The following objectives have been used while drawing the figures:—

Swift, 1 inch,	magnifies	45 times.	Zeiss, $\frac{1}{12}$ oil-immersion, magnifies 950 times.
,, $\frac{1}{4}$,,	,,	225 ,,	
,, $\frac{1}{8}$,,	,,	300 ,,	

The following system of lettering has been adhered to throughout:—

cras., craspedum.
cut., cuticle.
ec., ectoderm.
ec. cæ., ectodermal cæca.
en., endoderm.
en. cæ., endodermal cæca or tubules.
g. t., gastric tube.
i. my., intermesenteric chamber.
i. t., invaginated tube.
lac., lacuna in mesoderm.
lo., lobe.
m., mouth.
mes., mesoderm.
m. f. c., circular muscular fibres.
m. f. l., longitudinal muscular fibres.
m. my., mesenteric muscles.
my., mesentery.
n. c., nerve cells.
nem., nematocyst.
p., polype.
sp., spicule.
st., stolon.
tn., tentacle.
tn. p., pinna of tentacle.

PLATE I.

Fig. 1. A colony of *Sarcodictyon catenata* (Forbes), red variety,—natural size.

Fig. 2. Part of another colony, showing several polypes on a common expanded stolon,—natural size.

Fig. 3. Part of another colony with rather a thick stolon,—natural size.

Fig. 4. Part of a colony of the yellow variety, from Loch Fyne,—natural size.

Fig. 5. A polype in the retracted condition,—enlarged.

Fig. 6. The same seen from above, showing the anterior end,—enlarged.

Fig. 7. Anterior end of another polype not completely retracted,—enlarged.

Fig. 8. Anterior part of an expanded polype, from the side,—enlarged.

Fig. 9. Three of the pinnate tentacles dissected off to show their cavities,—enlarged.

Fig. 10. A single tentacle, with a very small tip,—enlarged.

Fig. 11. End of a tentacle with no tip, terminating in a pair of pinnæ,—enlarged.

Fig. 12. Dissection of the front part of the body, to show the elevated mouth between the tentacles,—enlarged.

Fig. 13. Vertical section of the upper part of a retracted polype, such as Fig. 5. Objective—Swift, 1 inch.

Fig. 14. Transverse section of a polype along A B in Fig. 13. Objective—Swift, 1 inch.

Fig. 15. Small portion (*en.*) of last Fig. more highly magnified. Objective—Swift, $\frac{1}{8}$ inch.

Fig. 16. Transverse section of polype along C D in Fig. 13. Objective—Swift, 1 inch.

Fig. 17. Central part of another section similar to last. Objective—Swift, 1 inch.

Fig. 18. Transverse section of polype along E F in Fig. 13. Objective—Swift, 1 inch.

Fig. 19. Oblique section of polype along line G H in Fig. 13 (upper edge of Figure corresponds to G, lower to H). Objective—Swift, 1 inch.

PLATE II.

Fig. 1. The colourless spicules of a small portion of the young stolon of the yellow variety, Loch Fyne. In their natural positions. Objective—Swift, 1 inch.

Fig. 2. *a* to *l* selected spicules from same stolon as last Fig. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 3. Shape of the simple spicule, diagrammatic.

Fig. 4. Small portion of colourless spicule from stolon more highly magnified. Objective—Swift, $\frac{1}{8}$ inch.

Fig. 5. Mass of red spicules from the body wall in their natural positions. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 6. Some selected red spicules from a young stolon, red variety. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 7. The ectoderm and its cuticle from the body wall, surface view. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 8. The same in profile view. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 9. One of the craspeda, surface view as exposed in dissection. Objective—Swift, 1 inch.

Fig. 10. Part of a tentacle to show its spicules. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 11. Some spicules from a tentacle. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 12. Part of one side of a tentacle, showing the cavity and the longitudinal muscles. Objective—Swift, 1 inch.

Fig. 13. Small part of last figure more highly magnified to show muscles, etc. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 14. Longitudinal section through the wall of the tentacle to show its structure. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 15. Small portion of the surface of a mesentery in upper part of body. Objective—Swift, $\frac{1}{4}$ inch.

Fig. 16. Part of a section through the mesoderm of the body wall, to show the tubules and lacunæ. Objective—Swift, $\frac{1}{8}$ inch.

PLATE III.

Fig. 1. Part of a transverse section through the upper part of a retracted polype. Objective—Swift, $\frac{1}{8}$ inch.

Fig. 2. Transverse section of part of the body wall and a mesentery, in lower part of polype. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 3. Transverse section of part of another mesentery to show the muscle fibres. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 4. Half of a transverse section through the gastric tube, etc. Objective—Swift, 1 inch.

Fig. 5. Small portion of a tranverse section through upper part of retracted polype. Objective—Swift, $\frac{1}{8}$ inch.

Fig. 6. Another small portion of a similar section, to show the ectodermal cæca. Objective—Swift, $\frac{1}{8}$ inch.

Fig. 7. Small part of optical section of a mesentery, showing nerve cells. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

Fig. 8. Part of a transverse section through the gastric tube. Objective—Zeiss, $\frac{1}{12}$ oil-immersion.

II. *Notes on the Islands of Sula Sgeir, or North Barra and North Rona, with a List of the Birds Inhabiting them.* By JOHN SWINBURNE, Esq.

(Read 19th December 1883.)

In the early part of this season, 1883, as our yacht the "Medina" was lying idle at her moorings, I determined to start for a cruise among the Outer Hebrides, intending to visit, among other places, Hysgeir off Canna, and the Flannan and Shiant Islands—all of them localities which have been made well known to the ornithological world by the very full descriptions that have been given of them by Mr Harvie-Brown.

Mentioning my intention to my friend, Mr Dalgleish, he

suggested that as I had a good, sea-worthy craft, I might as well extend my cruise to Sula Sgeir and North Rona, which were comparatively unknown. This I succeeded in doing, and imagining that my account might be of interest, I wrote out a short description of my visit. Since returning home I have been able, through the kindness of Mr Dalgleish, to obtain several extracts from notes made by visitors to both Sula Sgeir and Rona, which are given below, though few of them refer to ornithology.

On Monday, June 18, I left Stornoway, in the yacht for Ness Harbour, near the Butt of Lewis, where I wished to get a pilot, and at 2 a.m. on Tuesday morning I was awakened and told that we were off Ness.

Going on deck, I found we were off the Butt of Lewis, in a dead calm, with a ground swell rolling in from the north-west, such as I have seldom seen. The boat was lowered with great difficulty, and I proceeded ashore.

Ness is a very strange place, being a large bay open to the south-east, the top of which is formed by a stretch of beautiful white sand, on which a heavy surf breaks continuously. The sides are formed by broken cliffs, and on the north side of the bay is the so-called harbour, which is merely a slip where the fishermen haul up their boats.

I had considerable difficulty at first in getting any one to volunteer to act as pilot, as all the men were just going out to haul their lines, but at last a man of the name of Norman MacLeod came forward. I give the name in case any one intending to visit Sula Sgeir or Rona should want a good pilot who knows the ground thoroughly. I should strongly advise any future visitor to get a pilot from Ness, as the Stornoway pilots are a terrible set of land-sharks.

Leaving Ness about 5 a.m. on the 19th, we steered north-north-east for Sula Sgeir.

On the way out I got all the information I could out of the pilot. He said that some years ago he had lived for some time on Rona, tending the few sheep that are on the island, and that a great many birds bred there, and among them a bird which answered to the description of a petrel of some sort.

About 5 p.m. we sighted Sula Sgeir from aloft, a little on the weather bow, and shortly after Rona appeared further to windward. About 7 p.m. we were close to Sula Sgeir, so I ordered the boat to be lowered, at the same time telling MacLeod that we did not want him ashore. He smiled rather grimly without answering, but just as we shoved off he suddenly fell into the boat with a mighty crash, very nearly capsizing her. Evidently he had not the slightest intention of letting me loose among the gannets by myself. He seemed to look upon them as his own private property.

The landing-place we made for is on the east or south-east side of the island. I believe there is another and a better one on the north-west side, but there was a very heavy swell rolling in from that quarter.

The landing had to be effected on a very steep rock by watching for an opportunity, and then making a wild leap at the shore before the boat fell for the next sea.

As soon as we were safe ashore, MacLeod made straight for the south-western end of the island where the gannets were, and he stuck to me like a leech the whole of the time I was anywhere near this enormous gannet nursery.

The nests were placed chiefly on the level top of the island and not on the cliffs, and covered the whole of the western portion, being placed so close together that it was difficult to avoid stepping on the eggs. The greater number of the birds got up from their nests when I got within about three feet of them, but a good many remained sitting and bit at my trousers as I passed.

MacLeod had a very strong objection to my touching the gannets' eggs, because, as I afterwards found out from him, a boat comes out from Ness every autumn about the beginning of September, to take back a cargo of the young birds, which are salted down for winter food.

I was surprised to observe at this late date that only about 10 per cent. of the gannets' eggs were hatched, and I even took fresh ones, although most of the guillemots were hatching, and at the Bass most of the gannets are sitting by the end of April. On leaving the gannetry I went down a nasty cliff on the north side to get some guillemots' eggs, in spite of

the warning yells of MacLeod, who thought it a very mad exploit. I was fortunate enough to take several eggs of the bridled guillemot (*Lomvia troile*, var. *ringvia*) from under the sitting birds, thus thoroughly authenticating them.

Seeing that MacLeod had retired, either not wishing to behold my sad end, or intent on the slaughter of the luckless puffin (at which he was a great adept), I reascended the cliff, and made a second attack on the gannets, after which I turned my attention to the island itself.

The earliest account of the island of Sula Sgeir of which we have any record is that of Dean Munro, who visited it in 1549.

He says,[1] "be sexteen myle of sea to this ile (*i.e.*, Rona), towards the west lyes ane ile callit Suliskerry, ane myle lang without grasse or hedder, with highe black craigs and black fouge thereupon part of them." He goes on to say how the Lewis men come out for the feathers and young birds, and enters upon a long description of the manners and customs of a bird which he calls a "colk," and which is evidently the eider duck (*Somateria mollissima*), which I found breeding there in limited numbers. A subsequent visitor to Rona, Dr MacCulloch,[2] who visited it in 1819, but owing to a heavy sea was unable to land, gives a very short account of Sula Sgeir, only mentioning its being a great gannet resort. The last account we have is that of Mr T. S. Muir, who seems to have visited the island about 1860. I believe only about twenty copies of his notes were privately printed.[3]

He describes Sula Sgeir as "a narrow stripe of rock, little more than one-third of a mile in length. Rising in most parts to a considerable height, and everywhere ruggedly indented by gloomy chasms, pools, and creeks, it presents a very naked and repulsive appearance."

He then proceeds to state that the southern end, however,

[1] Description of the Western Isles of Scotland, called Hybrides, Edinburgh, 1774, p. 47.

[2] Description of the Western Islands of Scotland, London, 1819, p. 204.

[3] Inchcolm, Aberdour, North Rona, Sula Sgeir; A Sketch, addressed to J. Y., Minster Yard, Lincoln, p. 34.

is in part grassy. This, I think, is an error, as I only saw a few patches of the common sea pink (*Armeria maritima*). He also refers to the existence of the ruins of several stone huts or houses near the south-east end, and says that near the same spot are those of a small cell called Tigh Beannaichte (Blessed house), 14 feet long, the width varying from 8 feet in the centre, to 6 feet 4 inches at the ends. The roof is curved and covered with stone slabs. The door, which is placed on the south-west side, is 3 feet 5 inches in height. There is also a small window in the east end, under which is an altar stone 2 feet 8 inches in length. MacLeod informed me that the huts were built by the Lewis men, who live in them for the seven or eight days they take in killing and packing the young gannets, or any longer time they may have to stay on the island, owing to the sudden springing up of a gale.

The cell mentioned by Mr Muir was probably erected for the use of those who came from Rona or Lewis for a similar purpose in Roman Catholic times. On one occasion, now some years ago, a crew from Ness in the latter island had their boat wrecked in landing at Sula Sgeir in the month of June, and lived on the island for several weeks, sustaining themselves on the flesh of birds. Captain Oliver, who commanded the Revenue cruiser "Prince of Wales," visited Sula Sgeir in the month of August to look for the lost boat. He found the wreck of it, also an oar on end with an old pair of canvas trousers on it, and over the remains of a fire a pot containing birds' flesh; but there being no trace of the men, it was thought they must have been picked up by a passing vessel. Nothing more was heard of them until the month of October following, when a Russian vessel on her homeward voyage met a Stornoway craft in the Orkneys, and informed the crew of the latter that they had taken the men off Sula Sgeir and landed them in Rona. Captain Oliver at once went to Rona, and found the crew consuming the last barrel of potatoes which the poor shepherd had. He took away the former, and left the latter sufficient provision for the winter. Having thus quoted all the published descriptions of Sula Sgeir that I know of, I shall proceed with my own notes.

Dean Munro's ideas of distance seem to be a little vague, as the chart makes Sula Sgeir about 10 miles west by south of Rona.

Sula Sgeir is about half a mile long by about 300 yards wide at the narrowest part, which is just opposite the landing place we used. It lies about north-east and south-west. The western end forms a steep, rocky bluff, tolerably level on the top. The island slopes downward in the centre, and rises again into a rounded mass of rock at the eastern end. The whole of the western end is surrounded by steep cliffs, and has its upper surface covered with huge blocks and slabs of stone, among the crevices of which a few sea pinks grow. It is on this part and not on the east end that the huts, about three in number, are situated. They are indeed curious looking erections, being built of huge blocks of stone piled up together, and generally having no other opening than the door. Most of them were about 8 feet by 5 feet, by 4 feet high. At the time of my visit they were tenanted chiefly by cormorants, which built in them.

One of the yachtsmen excitedly described to me how, having crawled into a hut with the innocent intention of examining its interior, he was immediately attacked by a terrible black bird, which scratched and bit him, all the while giving vent to the most appalling croaks and groans, and how, after a tremendous battle in the dark, the enemy was slain, and being brought to daylight, turned out to be "jist only one o' them scarfs."

About eleven o'clock I got on board again, and we stood over towards Rona, under the lee of which I wished to heave to until daylight. Coming on deck after dinner, that is about eleven o'clock at night, I found that the clouds had banked up to the east, that it was blowing pretty hard, and altogether looked like bad weather. The pilot sent word to say that he thought we were going to have a heavy gale, and as this appeared also to be the opinion of the crew, I set the course by compass for the Butt of Lewis.

While standing near the binnacle, my nostrils were suddenly assailed by a most villainous odour; while, at the same moment, the crew rushed on deck *en masse.* On making

inquiry I found that the pilot, to save himself the trouble of wholly plucking some razorbills which he wished to cook, had held them over the stove to singe off the feathers.

After running towards the Butt of Lewis for about two hours, as the weather got no worse, we went about and stood back towards Rona, which I was very loth to leave unvisited.

At about three on Wednesday morning, June 20th, we left the yacht to land on Rona.

There are one or two places where a boat can land in moderate weather on this island, we chose a slight indentation near the centre of the south side owing to the heavy north-westerly swell which was still running. On landing we had to drag the boat up a very steep rock, and then jam stones under her to prevent her from slipping down again.

Before I enter upon my own description of Rona, I shall give a few extracts from notes made by previous visitors.

The earliest published account of Rona that I am aware of is that of Dean Munro before referred to. He gives a very quaint description of the island and its inhabitants—for there were then several families on the island—speaking of them as "simple people scant of ony religione," although a little further on he says, "within this ile there is ane chappell callit St Ronay's chappell."[1]

He states that "abundance of corn growes on it by delving onlie," also that the meal made therefrom, which was very white, was sufficient to feed the people and pay their rents, together with the "superexcrescens" of a number of "ky and schiepe" kept by them.

Speaking of St Rona's Chapel, Dean Munro mentions the following curious superstition of the natives: "unto quhilk chapell, as the ancients of the country alledges, they leave an spaid and ane shuil quhen any man dies, and upon the morrow findes the place of the grave markit with an spaid as they alledge. In this ile they used to take many quhailles (whales) and uthers grate fisches" (fishes).

"Rona" means the "Island of the Seals," therefore the saint must have taken his name from the island, and not

[1] Miscellanea Scotica, ii., p. 152.

the island its name from the saint, as might possibly be thought.

Another author of a somewhat later period, in a "Description of the Lews by John Morisone, Indueller there,"[1] gives the following particulars about Rona:—

"There are also, 17 leagues from the Lews, and to the north of it, the islands called Suliskerr, which is the westmost, and Ronay, fyve myls to the eas[t] of it; Ronay (onlie) inhabited, and ordinarlie be five small tennents. There ordinar is to have all things common: they have a considerable grouth of victuall (onlie bear). The best of their sustinance is fowl, which they take in girns, and sometimes in a stormie night they creep to them where they sleep thickest, and throwing some handfulls of sand over there heads as if it wer hailes, they take them be the necks. Of the grease of those fowlls (especiallie the Solind Goose) they make an excellent oyle, called the gibanirtick, which is exceeding good for healing of anie sore ore wound ore cancer, either one man or beast. This I myself found true by experience, by applying of it to the legg of a young gentleman which had been inflamed and cankered for the space of two years, and his father being a trader south and north, sought all phisicians and doctors with whom he hade occasion to meet, but all was in vain. Yet in three weeks tyme, being in my hous, was perfetlie whole be applying the forsaid oyle. The way they make it is—they put the grease and fatt into the great gutt of the fowll, and so it is hung within a hous untill it run in oyle. In this Ronay are two litle cheapels where sanct Ronan lived all his tym as an heremit."

About the end of 1600, Sir G. Mackenzie of Tarbert gave a not much longer account to Sir Robert Sibbald,[2] of the island, in which he states that for many generations the island had been inhabited by about 5 families or about 30 individuals, and that these numbers never increased, because if any one man had more children than another he gave some to his neighbours, and any surplus above 30 souls was sent to Lewis by a boat which went for the rent paid to the Earl

[1] Sibbald MSS., Advocates Lib., Ed., xxxiv., 2-8.

[2] Printed in Monro's Description of the Western Isles, Edinburgh, 1774, p. 63.

of Seaforth in the form of meal packed in sheep-skins, and sea-birds' feathers. The inhabitants seem to have met twice or thrice daily in the chapel, and to have been Roman Catholics. They had evidently become more pious since Dean Munro's visit.

Martin,[1] writing about the same date, gave a curious account of the island and its inhabitants as related to him by Mr Daniel Morrison, minister of Barvas in Lewis, who then appears to have possessed it as part of his glebe, and who had visited it in person. The minister mentions the chapel as being in use by the natives, and that they kept it very neat and clean. The houses he described as being thatched with straw. The next account is that of Dr MacCulloch the geologist, who seems to have visited the island in 1819. At the time of his visit there was only one cottar family left.

The Doctor, referring to Rona as it was about the year 1670, says:[2] "Some years have now passed since this island was inhabited by several families who contrived to subsist by uniting fishing to the produce of the soil. In attempting to land on a stormy day all the men were lost by the upsetting of their boat, since which time it has been in the possession of a principal tenant in Lewis. It is now inhabited by one family only, consisting of six individuals of which the female patriarch has been forty years on the island. The occupant of the farm is a cottar, cultivating it and tending 50 sheep for his employer, to whom he is bound for eight years, an unnecessary precaution, since the nine chains of the Styx could afford no greater security than the sea that surrounds him, as he is not permitted to keep a boat. During a residence, now of seven years, he had, with the exception of a visit from the boat of the 'Fortunée,'[3] seen no face but that of his employer and his own family."

In a note he also says, "On the appearance of our boat, the women and children were seen running away to the

[1] Description of the Western Islands of Scotland, London, 1703, p. 19.

[2] *Op. cit.*, vol. i., p. 206.

[3] Then employed in cruising after the President in 1812.

cliffs, to hide themselves, loaded with the very little moveable property they possessed, while the man and his son were employed in driving away the sheep. We might have imagined ourselves landing in an island of the Pacific Ocean. A few words of Gaelic soon recalled the latter, but it was some time before the females came from their retreat—very unlike, in look, to the inhabitants of a civilized world."

Speaking of the houses, Dr MacCulloch says, "Such is the violence of the wind in this region, that not even the solid mass of an Highland hut can withstand it. The house is therefore excavated in the earth, the wall required for the support of the roof scarcely rising two feet above the surface. The roof itself is but little raised above the level, and is covered with a great weight of turf, above which is the thatch—the whole being surrounded by turf stacks to ward off the gales. The entrance to this subterranean retreat is through a long, dark, narrow, and tortuous passage, like the gallery of a mine, commencing by an aperture not three feet high, and very difficult to find. With a little trouble this might be effectually concealed; nor, were the fire suppressed, could the existence of a house be suspected, the whole having the appearance of a collection of turf stacks and dunghills. Although our conference lasted some time, none of the party discovered that it was held on the top of the house. . . . The interior strongly resembles a Kamtschatkan hut, receiving no other light than that from the smoke-hole, being covered with ashes, festooned with strings of dried fish, filled with smoke, and having scarcely an article of furniture. Such is life in North Rona, and though the women and children were half-naked, the mother old, and the wife deaf, they appeared to be contented, well fed, and little concerned about what the rest of the world was doing."

There were then about six or seven acres under cultivation, the surplus crop of which was paid by the cottar to the tacksman in Lewis, and which amounted to 8 bolls of barley. He (the cottar) was also bound to find 8 stones of feathers, the produce of the sea-fowl, which, with the produce of the

sheep, was to the tacksman the value of North Rona. To the latter the land was let for £2 a year.

Such is Dr MacCulloch's account of North Rona.

Captain Burnaby, R.E., who had charge of the Ordnance Survey in Lewis about thirty-six years ago, gives the following description of the physical features of the island: "This island is situated in the Atlantic in latitude 59° 7′ 15″ 48, and longitude 5° 48′ 50″ 45 west, and forms part of the Lewes property, and lies about 38 miles N.E. of the Butt of Lewes, with which and Cape Wrath it forms a triangle, which is very nearly equilateral. From its highest point, which is nearly 360 feet above the level of the sea, Cape Wrath, a considerable portion of the neighbouring shore, and some of the Lewes and Harris hills can on a clear day be distinctly seen without the aid of glasses. In figure it bears a striking resemblance to a long-necked glass decanter, with the neck towards the north. Its greatest length is nearly one mile, its greatest breadth the same. At its north end there is a portion about half a mile in length, which varies in breadth from ten to twenty chains. About half of this portion is composed of stratified rock without a particle of vegetation. This is the lowest part of the island, its eastern shore sloping gently to the sea, and its western one, though rugged and broken, not more than 90 feet in altitude. The southern portion is broader and more elevated, the largest part of it being ¾ of a mile broad, and the two hills on the east and west not less than 350 feet high, that on the east being the higher of the two by about 40 feet; the seaward bases of both these hills form steep, precipitous cliffs, which in many places are inaccessible."

"The rocks around Rona are few and small, the only ones which are more than two chains from the shore being Gouldig Beag and Gouldig Mor; the latter is about half a mile south of the south-east point of the island, and the other is between that and the shore. There is another small rock seen only at low water near the south-west point, which is dangerous to navigators who may attempt to cast anchor in its neighbourhood. The soil of Rona is good, and the pasture, though not luxuriant, is beautifully green; indeed, the whole

island, with the exception of about 50 acres, may be considered arable land, interspersed with a few small rocks and numerous small piles of stones. . . . There are neither rats nor mice on it. It has no peat moss, and not much seaweed. There is a sufficiency of spring water on its southern shore. Seals are very numerous here, but not easily killed, and cod-fish abound around its coast. The tides rise from 5 to 10 feet, and the prevailing wind is from the south-west. The best landing places are Poul Houtham on the south, Skildiga on the west, and Geodh Sthu on the east—the first and last being much superior to the other both for safety and accommodation. The most favourable winds are—for Poul Houtham a northerly or easterly wind, for Geodh Sthu a southerly or westerly one, and for Skildiga a southerly or easterly one. So well sheltered is Geodh Sthu that three vessels have been known to cast anchor at its mouth about six years ago. They remained during one night, but it is said that such had not previously occurred, nor has it been since repeated. Articles of any weight may be safely landed at Rona providing the weather is moderate, but the small boat, which must be used on such a duty, should invariably be drawn up on the shore after use." [1]

The last published account of Rona is that by Mr T. S. Muir, previously referred to, bearing date 1872.[2] He seems to have visited Rona on two occasions, on the last of which (in 1860) he took careful measurements of the chapel referred to by Dean Munro and Mr Morrison, and to these measurements he has added a plan and sketch of this ancient building, which he describes as a roughly-built cell, 11 feet 6 inches by 7 feet 6 inches, and 9 feet 3 inches high, with the side walls gradually sloping inwards until they are only 2 feet apart at the roof. There is a low square doorway in the west end, through which it is necessary to creep on one's hands and knees; there are also two windows—one over the door, the other near the east end of the south wall. The altar-stone lies near the east end, and is 3 feet long. The remains of another chapel are attached to the building, forming a sort

[1] Original, dated 1850, in Ordnance Survey Office, Southampton.
[2] *Op. cit.*, p. 16.

of nave to it, the internal measurement of which is 14 feet 8 inches by 8 feet 3 inches. The masonry is very rude, and seems of great age, certainly of some centuries. A burying-ground, surrounded by a low stone wall, is attached to the building, and contains several plain stone crosses, the tallest of which is about 30 inches high. I shall now proceed with my own short notes.

Mr Muir's description of the chapel is so accurate that I need hardly say anything more about it. The appearance also of the ruins of the houses fully corroborated Dr MacCulloch's description. I was struck at once by the great thickness of the walls, as well as by the fact that the terreplein of the interior was sunk below the level of the surrounding ground. The last family which lived upon Rona was that of a shepherd named Donald M'Leod, otherwise the "King of Rona," who returned to Lewis in 1844; since which time it has been uninhabited, except for a few days at the annual sheep-shearing at the end of July.

The island has been rented for upwards of 230 years by a family named Murray from Lewis, who only gave up their tenancy in the present year. They usually kept from 100 to 160 sheep of the blackfaced breed upon it, but occasional losses from their falling over rocks or being stolen by the crews of passing vessels were not infrequent. On one occasion, however, the owners of a vessel whose crew had, through scarcity of provisions, been tempted to "lift" a few sheep, honourably sent a sum of money in payment. It has now been let to Mr Finlay Mackenzie, Habost, Ness, in the island of Lewis. The late tenant informed Mr Muir that the rent paid by the resident sub-tenants of Rona, at an early period considerably before his family became tenants, was partly in the form of seal oil. I saw on the island about forty or fifty sheep, which seemed to be very wild.

As soon as we landed, I made straight for the place where the pilot said the petrels bred. This turned out to be the spot where all the ruins are situated, namely, pretty low down on the grassy slope near the western end of the island. We were all soon at work hauling out large stones, and scraping with our hands, guided by the strong musky odour

which pervaded the inhabited burrows which run through and through the thick walls of the old buildings, the latter of which, mixed with earth and turf as they were, afforded unequalled facilities to the birds for the purpose.

Five minutes' steady digging, and the first petrel with its egg was brought to light. I examined it eagerly, and was delighted to find it was a specimen of Leach's, or the fork-tailed petrel (*Procellaria leucorrhoa*). Subsequently we dug out twenty-two more, with their eggs, all within an hour and a half, and could easily have obtained a great many others had we wished.

This colony is, I therefore imagine, one of the principal breeding stations of this species in the Eastern Hemisphere, and certainly the largest in Great Britain, the only other yet known being on one of the St Kilda group, found by Sir William Milner in 1847. Mr Gray also states, in his work on the "Birds of the West of Scotland," that it breeds on the island of Rum; but this, I should think, requires corroboration. I have searched the portion of the island mentioned twice without finding any traces of them, and other ornithologists have been equally unsuccessful. I cross-questioned several of the Rum shepherds, who at first said that petrels did breed on that island; but when I asked them to describe the bird, they accurately described the Manx shearwater (*Puffinus anglorum*), which does breed in Rum in great numbers, and where I have taken their eggs. Mr Elwes, in his article on "The Bird Stations of the Outer Hebrides,"[1] mentions it breeding, along with the stormy petrel, on Berneray or Barra Head island, but does not give certain data. The Leach's petrels on Rona seemed to build in small companies, one large main burrow in the walls of the ruins serving for several pairs of birds, which made smaller burrows branching off at right angles to the main one.

I found a burrow on the top of the hill at the east end of the island, so I imagine they breed all over the island wherever there are suitable situations.

Leaving the petrels, I started to explore the island. I was rather surprised to find a small flock of curlews among the

[1] *Ibis*, 1869, p. 20.

long grass near the centre. They were very wild, and I could not procure a specimen, which I very much wished to do.

As we were returning to the boat I observed a number of seals on an outlying rock, but as they did not permit of a near approach, I could not determine the species.

The rock of which both Rona and Sula Sgeir are composed is, according to MacCulloch, gneiss, alternating with beds of hornblende schist, equalling or exceeding it in quantity, and traversed by granite veins.

About twelve noon I returned on board the "Medina," and having seen all sail made, turned in, with the gratification of imagining that I had contributed my small mite in the way of ornithological discovery.

List of birds observed on Rona and Sula Sgeir :—

Falco peregrinus (Tunstall), Peregrine Falcon.—I observed a pair of these birds hovering near the south-west part of the cliff on North Rona, where, I have no doubt, they had a nest, from the outcry they made when that portion of the island was approached.

Saxicola œnanthe (Linn.), Wheatear.

Anthus pratensis (Linn.), Meadow Pipit.

Anthus obscurus (Lath.), Rock Pipit.

These three species I observed on Rona only, and only in very small numbers.

Phalacrocorax graculus (Linn.), Shag.—This species was largely represented on both islands. On Sula Sgeir they bred in the huts and under the large stones, while on Rona they bred in the crevices and fissures of the cliffs, and under the rocks which had fallen from above.

Sula bassana (Linn.), Gannet.—The gannets now breed only on Sula Sgeir, to which they may give the name. Gannets are said to have bred at one time on Rona, but on this point we have no authentic information. If true, I imagine the nests must have been placed on the cliffs. Some idea of the vast numbers of gannets frequenting Sula Sgeir during the breeding season may be formed from the fact that from 2000 to 2500, and in some years as many as 3000 young birds are taken, being more than double the number

which are got from the Bass Rock in the Firth of Forth, where in some years not more than 800 are obtained.

Somateria mollissima (Linn.), Eider Duck.—Very plentiful on Rona, building among the grass at some distance from the water. I also took a nest with four fresh eggs on Sula Sgeir.

Hæmatopus ostralegus (Linn.), Oystercatcher.—Several pairs were found on North Rona, where I took a nest on the verge of the cliff at the height of about 200 feet. I never saw an oystercatcher's nest in so exalted a position before.

Numenius arquata (Linn.), Curlew.—About five or six pairs near the centre of North Rona. They were very noisy, and I think were breeding, although, as might have been expected, we could not find the young birds. I was sorry I could not shoot a specimen, as it seemed to me to be a strange place for curlews.

Larus argentatus (Gmel.), Herring Gull.—I noticed several pairs of these birds on Rona, but was unable to get any of their eggs.

Larus marinus (Linn.), Greater Black-Backed Gull.—There was a large colony of these birds on the low point at the western end of Rona, just below where the ruins are situated. The ground was all littered over with feathers, nest material, etc., and the young birds were to be seen hiding under the stones, while the old ones created a terrible din overhead, now and then swooping down unpleasantly near the heads of the intruders into their haunts. I did not notice any lesser black-backed gulls (*L. fuscus*), though I have no doubt they were there.

Rissa tridactyla (Linn.), Kittiwake.—A large colony of these birds on the north side of Sula Sgeir; also another on the north-west side of Rona, where there are some very large caves. Both these places are practically inaccessible.

Procellaria leucorrhoa (Vieill.), Leach's Petrel.—Found, as before stated, on Rona only, breeding in companies. I may note that I found no trace or appearance of the stormy petrel (*P. pelagica*) on either island.

Puffinus anglorum (Tem.), Manx Shearwater.—I could not find a nest of this bird on Rona, although I saw the bird

within a few miles of the island, and have no doubt that it breeds there.

Alca torda (Linn.), Razorbill.—Plentiful on both islands. On Sula Sgeir it breeds under the stones on the level surface of the island, while on Rona it lays its single egg in some hole or cranny near the top of the cliff.

Lomvia troile (Linn.), Guillemot.—Plentiful on both islands. On Sula Sgeir I was surprised to find it breeding on the level top of the island among the puffins and razorbills.

Lomvia troile, var. *ringvia*, Bridled Guillemot.—I noticed a good many birds of this variety on Sula Sgeir, where I was fortunate enough to take several eggs from under the birds.

Uria grylle (Linn.), Black Guillemot.—There were a good many of these birds about the west end of Rona, where I took one egg. I did not see any on Sula Sgeir.

Fratercula arctica (Linn.), Puffin.—This species simply swarmed upon both islands. On Sula Sgeir they were to be found under the stones, and on Rona all round the island wherever they could burrow. A considerable number of the young are annually taken for the purpose of being salted for food in the same manner as those of the gannets. This is, however, done at an earlier period—viz., about the end of July, at the same time as the sheep-shearing takes place on Rona. From 500 to 1000 are thus captured; they are either extracted from their nests by means of a hook tied to the end of a stick about 2 feet long, or, if they have left the nest a noose attached to the extremity of a long rod is slipped over their head as they sit on the rocks.

III. *Remarks on the Genus* Megalichthys (*Agassiz*), *with Description of a New Species.* By Dr R. H. TRAQUAIR, F.R.S. [Plate IV.]

(Read 20th February 1884.)

There can be no doubt that the name *Megalichthys* was originally suggested to Agassiz by the gigantic teeth of the great round-scaled fish first brought into notice by the re-

searches of Dr Hibbert in the quarries of Burdiehouse, though indeed some of its remains had long previously been figured by Ure in his "History of Rutherglen and East Kilbride." Uncontrovertible evidence of this may be found by referring to the *Proceedings* of the British Association for 1834, and to Dr Hibbert's original memoir on the Burdiehouse Limestone, published in the *Transactions* of the Royal Society of Edinburgh, vol. xiii., 1835. But with the remains of this enormous creature were also associated and confounded certain rhombic glistening scales, belonging really to a considerably smaller fish of a totally different genus, and when Agassiz, subsequently to the meeting of the British Association at Edinburgh in the year above quoted, found in the Museum at Leeds a head of this latter form, or at least of an allied species, he adopted *it*, by description and by figure, as the type of his *Megalichthys Hibberti*,[1] relegating the other to the genus *Holoptychius*. This latter, the real "big fish," is now known as *Rhizodus Hibberti*, the founder of the genus being Professor Owen; and though it may be a matter of regret that it did not retain the name *Megalichthys*, the laws of zoological nomenclature do not admit of any alteration now.

The brilliantly enamelled scales, head-plates, and teeth of *Megalichthys* are among the commonest vertebrate remains found in the estuarine beds of the Carboniferous epoch in Great Britain; nevertheless specimens showing the fish itself in any but a very fragmentary state are rare, and though the head is very well known, from the magnificent specimen at Leeds figured by Agassiz, no concise description of the configuration of the body or of the arrangement of the fins has yet been given. It was classed by Agassiz in his heterogeneous group of "Sauroïdes," but the resemblance of its scales and head-plates to those of the Old Red Sandstone genera *Osteolepis* and *Diplopterus* did not escape the attention of Sir Philip Egerton, who in Morris's "Catalogue of British Fossils" proposed its reference to the family of "Sauroidei-dipterini" (*Sauroïdes-dipteriens*), instituted by Agassiz for Dipterus and the genera just mentioned. From this group,

[1] Poissons Foss., vol. ii., pt. 2, pp. 89-96, Pl. 63, 63*a*, and 64.

however, M'Coy very properly struck out *Dipterus*,[1] which from its rounded scales he classed as a "Coelacanth," and which we now know is in fact a Dipnoan, allied to *Ceratodus*. The probable position of *Megalichthys* in the "Saurodipterini," was also indicated by Pander, who mentioned its close relationship to *Osteolepis* in the arrangement of its head bones, the shape of its scales and teeth, and, above all, in the microscopic structure of its hard parts, though he also seemed to hesitate, on account of our want of knowledge, of the conformation and position of its fins.[2] A similar opinion, coupled with a similar hesitation, is expressed by Professor Huxley in his well-known Essay on the Classification of the Devonian Fishes.[3]

Professor Young, in a paper on "Carboniferous Glyptodipterines,"[4] makes some observations on *Megalichthys*, including a statement that, "since 1861, specimens illustrating the form of the fins have been acquired by the Museum (Jermyn Street), but the description and illustration of these parts are reserved." I am not aware of any account of these specimens having been yet published. An important point is, however, his abolition of M'Coy's genus *Centrodus* as a mere synonym of *Megalichthys*. *Centrodus* was founded upon a detached tooth from the coal-measures of Carluke, Lanarkshire.

Mr J. Ward in a paper on the "Fishes of the North Staffordshire Coal-field," classes *Megalichthys* in the family Saurodipterini, and states, moreover, that in a specimen in his collection the pectoral fins are well preserved;—"They are lobate, *i.e.*, the central portion of the fin is covered with scales, the fin-rays forming a fringe round the lobe."[5]

There can be no doubt that the position of *Megalichthys* is in the family of Saurodipterini, as defined by Pander, and adopted by Huxley and other writers. In every matter of

[1] British Pal. Foss., p. 590-592.

[2] Die Saurodipterinen, etc., des devonischen Systems, p. 5.

[3] Dec. Geol. Survey, x., 1861, p. 12.

[4] Quart. Jour. Geol. Soc., xxii., 1866, pp. 596-608.

[5] North Staffordshire Nat. Field Club; Addresses and Papers. Hanley, 1875, p. 228.

"family" importance, its structure conforms closely to that of *Osteolepis*.

The resemblance of the scales in external form is sufficiently obvious to every one, and their close correspondence in microscopic structure may be seen by comparing the figures of transverse sections given by Williamson in *Megalichthys*,[1] by Pander in *Osteolepis*.[2]

As regards the osteology of the head, the resemblance is exceedingly close between *Megalichthys* and the Old Red Saurodipterines, as is at once evident on comparing the figure of the head of *Megalichthys* given by Agassiz[3] with those of *Osteolepis* given by himself, by Hugh Miller,[4] and by Pander. It is not within the scope of the present paper to enter into a minute or even a general account of Saurodipterine cranial osteology; a few points may, however, be conveniently alluded to.

1. The polygonal plates covering the ethmoidal region between the frontals and the præmaxillæ are often more or less distinct in *Megalichthys*, as in small specimens of *Osteolepis*; often they are fused with each other, and with the adjacent bones named above, as seems always to be the case in *Diplopterus*.

2. Though Agassiz made a singular mistake with regard to the nasal openings of *Megalichthys*, he was perfectly correct in recognising the anterior position of the orbit, and in assigning to it a situation exactly corresponding to that in *Osteolepis*. Professor Young of Glasgow has, however, in a brief notice of a head of *Megalichthys* belonging to Mr John Smith, Kilwinning, Ayrshire,[5] stated that the two outer plates of the posterior half of the cranial shield, which he calls "anterior frontal" and "squamosal" (*posterior frontal*, and *squamosal* of the nomenclature adopted by myself), bound the orbit above. This would certainly put the orbits into a position very different to that which they occupy in *Osteolepis*. By the kindness of Mr Smith, I have had an

[1] Phil. Trans., 1849, Pl. xlii., Fig. 18.
[2] Saurodipterinen, etc., Pl. v., Fig. 8.
[3] Poissons Fossiles, Atlas, vol. ii., Pls. 63 and 63*a*.
[4] Footprints of the Creator, Figs. 12-15.
[5] Proc. Geol. Soc., Glasgow, iii., 1868, pp. 202, 203.

opportunity of examining the specimen in question, and though I find that on one side there is in the position indicated a triangular space formed by a displacement of the adjacent cheek-plates, I fail to see how it can be interpreted as an orbit, while, on the other hand, the position of the real orbit can, I think, be readily enough recognised in the place where we would expect to find it.

3. I have not seen in any specimen of *Megalichthys* the foramen which occurs between the frontal bones in *Osteolepis* and *Diplopterus.*

4. Although omitted in Miller's and Pander's figures, lateral jugular plates are undoubtedly present in *Osteolepis* and *Diplopterus,* as well as in *Megalichthys.*

The microscopic structure of the teeth of the Old Red Sandstone Saurodipterines is not yet fully elucidated ; so far, however, as external shape goes, there is nothing of sufficient importance to exclude *Megalichthys* from the group.

Then as regards the fins. The Saurodipterini have obtusely lobate pectoral and ventral fins, two narrow dorsals, one similarly shaped anal, and a caudal which may be heterocercal (*Osteolepis*) or diphycercal (*Diplopterus*). *Triplopterus* of M'Coy, supposed by him to have only one dorsal fin, is a genus which is really non-existent, as it was founded on a specimen of *Osteolepis,* compressed in such a manner as to show both ventral fins, one of which was mistaken for the single dorsal. The dorsal fins vary in position in *Osteolepis* and *Diplopterus,* being in the latter opposite the ventrals and anal respectively, while in *Osteolepis,* the first dorsal is in advance of the ventrals, and the second opposite the space between the ventrals and the anal. Now we have already seen that the lobate form of the pectoral in *Megalichthys Hibberti* was not unknown ; it is noticed by Mr Ward,[1] and was indeed incidentally alluded to long before by Agassiz [2] himself in describing what he supposed to be the ventral fin of *Glyptolepis,* but which was in reality a portion of the pectoral.[3] A specimen from the coal-measures of Dalkeith, in the Edinburgh Museum of Science and Art, shows also very

[1] *Loc. cit.* [2] Poissons Fossiles du vieux Grès rouge, p. 63.

[3] Pander, *op. cit.*, p. 68 ; Huxley, *op. cit.*, p. 7.

clearly the obtuse scaly central lobe with its fringe of fin rays.

As regards the other fins, their number and position are clearly shown in a specimen from the coal-measures of Airdrie, Lanarkshire, in the British Museum. There are two posteriorly situated dorsal fins, which are placed as in *Diplopterus*, the first opposite the ventrals, the second very nearly opposite the anal. Part of the caudal is shown, but it is unfortunately not in a very perfect condition.

The best display which I have seen of the fins of *Megalichthys* is, however, in the specimens from Burdiehouse, which form the special subject of the present communication.

No doubt, in applying the name *Megalichthys Hibberti* to the specimen at Leeds, Agassiz believed that he had before him the head of the same species, whose rhombic enamelled scales he had previously seen from Burdiehouse at the Edinburgh meeting of the British Association: there was not indeed material at the time for deciding otherwise. But the Burdiehouse *Megalichthys* is now represented by more than a few detached scales and bones, the entire contour of the fish, the arrangement of the fins, and many details regarding the head being displayed in specimens in the Edinburgh Museum and in other collections. Now, there are certain points which satisfy me pretty fully that the Burdiehouse fish is different specifically from the common coal-measure form of which the head at Leeds is the type, and it might indeed be disputed whether the former has not a prior claim to the specific name "*Hibberti*," especially as some of its scales and bones were actually figured under that name, along with remains of *Rhizodus*, by Dr Hibbert in his classical memoir, before the publication of Agassiz' account of the latter in the "Poissons Fossiles." But the fact that Agassiz, the founder of the genus and species, definitely adopted the Leeds specimen as the type of the first scientific description of *Megalichthys Hibberti*, coupled with the natural feeling that, except on really imperative grounds, it is not wise to disturb long established names, is, I think, sufficient justification for allowing it to retain the name which it has borne now for forty years.

Proceeding now to the description of specimens, the first

which may be noticed is one in the Edinburgh Museum (Hugh Miller Coll.), which is pretty entire though small (Pl. IV., Fig. 1). It measures $10\frac{3}{4}$ inches in length, though it must be noted that the rays of the caudal fin are somewhat frayed and broken at their extremities: the greatest depth of the body is $1\frac{3}{4}$ inch; the length of the badly preserved head is $2\frac{5}{8}$ inches. The pectoral fin is not shown, but all the others are, though perhaps not in so complete a state of preservation as might be wished. There are two dorsal fins, of which the anterior one is the smaller, and commences $6\frac{1}{4}$ inches from the front, while the second arises $1\frac{1}{2}$ inch further back. The ventral arises opposite a point rather behind the origin of the first dorsal, while opposite the second dorsal is an anal fin of moderate size, but whose rays are unfortunately rather broken up. The caudal, is pretty well shown, but not so well as in the next specimen, in which the form of the tail and of the second dorsal and anal are exceedingly well displayed. Fig. 2 represents the caudal extremity of this specimen, which is 14 inches in length, but originally it must have been considerably longer, as it wants the head, and, I should imagine, also a good bit of the body. The caudal fin here shown may be said to be somewhat intermediate between the diphycercal and heterocercal types, at least it is not quite so heterocercal as that of *Osteolepis*, and in general form reminds us of that of *Tristichopterus*. Rays arise from both the upper and lower margins of the body-continuation, but those of the lower side commence in advance of those of the upper. After the commencement of the rays, the upper margin of the body-prolongation slopes very little downwards, while on the other hand the lower one slopes very rapidly upwards, the two margins then converge to a point which is lost among the fin-rays, the scaly covering being lost at this part. The posterior margin of the fin slopes obliquely upwards and backwards, the greater number of the rays arising from the lower aspect of the body prolongation, while the apex, cut off in the specimen, would seem to be formed by rays arising from the upper or dorsal side of the axis.

On the dorsal aspect of the specimen, and just in front of the caudal, is the second or posterior dorsal fin. The anterior

margin of this fin measures $2\frac{1}{4}$ inches; it has a narrow scaly base, and expands somewhat distally; its apex is bluntly pointed. Opposite this, upon the ventral aspect, is the anal fin, of the same length, but rather more lanceolate in shape.

The pectoral fins are well shown in a specimen in my own collection; they are short and obtusely rounded, with an obtuse basal scaly lobe fringed with rays. The lobation of the ventrals seems to be not quite so marked.

All these fins are composed of numerous closely set rays, divided by very close transverse articulations, except quite at their proximal extremities, which are covered by the scales of the body; they dichotomise towards their extremities, and their free surfaces are brilliantly ganoid and punctated like the scales.

Scales.—The scales present the same appearance externally as in *M. Hibberti*, and are not to my eye distinguishable. Their internal surfaces are seldom seen, and appear sometimes furnished with the prominent keel seen in *M. Hibberti*, while in other instances this appears to be absent.

Vertebral Column.—A specimen in the Museum of Science and Art shows the presence of ring-shaped vertebral centra as in *M. Hibberti*.

Head.—Fig. 3 represents, reduced in size, a very instructive head in the Hugh Miller Collection, in which the cranial shield is very well shown. This is as usual divided across into two portions, an anterior or fronto-ethmoidal, and a posterior or parietal, but in this instance the anterior portion is longer by one-seventh than the posterior one; in *M. Hibberti*, on the other hand, the posterior moiety is the longer. Taking the parietal part of the buckler, it may also be seen to differ in shape from that in the ordinary species, in being proportionally broader in front. The plates of which it is composed seem pretty completely fused together as the indications of their original separation are slight and principally posteriorly. Near the hinder margin are also seen certain grooves like those observable in a similar situation on the cranial shield of *Osteolepis* and *Diplopterus.* One of these passes transversely across the middle of the squamosal element: another is V-shaped, one leg of the V continuing

the direction of the former across the posterior part of the parietal, from the outer margin to about the middle of the bone, whence the other leg then diverges outwards and backwards towards the posterior margin. These grooves in *Osteolepis* were supposed by Pander[1] to indicate the original presence here of elements equivalent to the transverse supra-temporal chain in *Polypterus,* but a careful examination of the under surface of Saurodipterine cranial shields, showing the sutures and centres of ossification, proves that this is not the case, and that the grooves in question are mere superficial markings. The supra-temporals are, according to my interpretation, represented in this family and in allied forms by the three plates, one median and two lateral, which lie immediately behind the shield, and which are lettered by Professor Huxley in *Glyptolæmus* as supra-occipital and epiotics.[2] The anterior or fronto-ethmoidal part of the shield in this specimen has its constituent elements completely anchylosed, so that not even the frontals are separately recognisable. On each side the margin is slightly excavated for the upper boundary of the orbit; the anterior margin is convex and expanded to form the rounded snout: the nasal openings are not visible. The whole surface of the buckler, besides the minute punctation of the glittering enamel, is covered with small scattered rounded openings, apparently the orifices of "mucous" ducts.

The posterior part of the cranial shield, detached, is well shown in another specimen. This, when compared with the corresponding part in *M. Hibberti,* shows the same greater proportional breadth in front seen in the last described example, but the sutures between its six constituent bones—viz., the paired parietals, squamosals, and posterior frontals—are distinctly marked; and the slime-canal apertures, similarly scattered over the surface, are very much smaller. The peculiar grooves on the posterior part of the shield, alluded to above, are also here so slightly marked as to require a lens for their definition.

[1] *Op. cit.*, p. 11.

[2] *Op. cit.*, p. 2, Fig. 2. On this subject see my memoir on *Tristichopterus alatus* (Trans. Roy. Soc., Edinb., vol. xxvii., 1875, p. 386).

Returning to the former head (Fig. 3), we find that though the operculars are gone, and most of the other superficial bones fractured and badly seen, the maxilla and mandible occupy their positions. The *Maxilla* (*mx.*), the anterior portion of which is deficient in this specimen, at once attracts attention by its narrow shape. It is shown in its entirety in the specimen represented in Fig. 4, when it is seen to differ from that of *M. Hibberti* in the much smaller depth of its posterior expanded portion, that being contained $4\frac{1}{3}$ times in its length, whereas in that species it is only contained about 3 times. The same fact being observable in two separate specimens, it cannot be looked upon as a mere accidental variety in shape.

The *mandible* (Fig. 5) seldom exhibits the oblique groove, indicating the original separation of the dentary element, which is so often observed in *M. Hibberti.* Jugular plates were present: *principal* (Fig. 6), *median*, and *lateral;* but these do not call for any special comment, nor do the opercular bones, which are sometimes found detached, and exhibit the ordinary shape.

The teeth are seldom seen; when visible they appear rather smaller in proportion than in *M. Hibberti*, though of the same general appearance.

The scales and superficial bones of the head have their free surfaces covered with a layer of smooth and brilliant ganoine, which under a lens shows a minute punctation quite similar to that in *M. Hibberti.*

The difference in shape of the maxilla, and of the parietal portion of the cranial shield are to my mind sufficient evidence that the *Megalichthys* of Burdiehouse is specifically different from *M. Hibberti*, but I have no doubt that when both species are more minutely examined and described, many other points of distinction will be found. For the form above described, which is certainly still less likely to be confounded with either the *M. coccolepis* or *M. rugosus* of Young and Thomson,[1] I propose the name of *Megal-*

[1] Proc. Brit. Assoc., 1869 (Exeter), Trans. of Sections, p. 102. As regards other species of *Megalichthys*, *M. maxillaris* (Ag.) was never described or figured; *M. priscus* (Ag.), from Orkney, was afterwards referred by Agassiz to *Polyphractus* (i.e., *Dipterus*); while *M. Fischeri* (Eichwald) is pronounced by Pander to be portion of the cranial shield of an *Osteolepis*.

ichthys laticeps. Possibly its remains may include those of *Diplopterus Robertsoni* (Ag.), said to be also from Burdiehouse, but as this is a mere MS. name, to the original of which there is now no clue, it must be simply cancelled.

Its remains are for the most part considerably smaller than those of the coal-measure species, though patches of scales occur showing that it sometimes attained a size nearly as great.

The fact that this species, of Calciferous Sandstone age, is distinct from any yet found in the Coal-measures, is in accordance with the result of all my experience in the domain of British carboniferous ichthyology; namely, that very few species of Ganoids are common to the strata above and below the Millstone grit. As regards *Megalichthys*, however, it must also be mentioned that its scattered remains are also not uncommon in the estuarine beds of the Scottish Carboniferous Limestone Series, but as yet I have seen no specimens on which any secure determination of species can be founded.

Explanation of Plate IV.

All the specimens figured are in the Edinburgh Museum of Science and Art.

Fig. 1. *Megalichthys laticeps* (Traq.), entire specimen, reduced : original, 10¾ inches in length. Hugh Miller Collection.

Fig. 2. Hinder extremity of another specimen, showing the second dorsal, anal, and caudal fins : reduced one-half.

Fig. 3. Head of another specimen showing the cranial buckler, maxilla, and mandible : reduced more than one-fourth. Hugh Miller Collection.

Fig. 4. Maxilla, from another head : natural size. Hugh Miller Collection.

Fig. 5. Mandible, reduced, and placed upright to save space : original, 2½ inches in length.

Fig. 6. Principal jugular plate, reduced : original, 2½ inches in length.

IV. *Notes on a Second Collection of Birds and Eggs from Central Uruguay.* By John J. Dalgleish.

(Read 19th March 1884.)

Since my former notes on this subject were published in the *Proceedings* of the Society,[1] I have received from my cor-

[1] Proc. Roy. Phys. Soc., vi., p. 232.

respondent in the Banda Orientál a further collection of eggs, accompanied, as previously, by the skins of the parent birds, and for the identification of the latter I am again under obligation to Mr Sclater. Continuing the numbers from my former paper, they are as follows:—

25. *Tinnunculus cinnamominus*, Sw.—native name "Halcon."—This is a southern form of *T. sparverius*, the American Kestrel, which latter is found throughout the whole of North America, but is replaced by the present species throughout the southern division of that Continent from the Straits of Magellan to New Granada, the States of Venezuela and Guiana excepted. *T. cinnamominus* differs in plumage from the typical *T. sparverius* chiefly by the want of the rufous patch on the crown in both sexes, which part in the former species is of a slatey grey colour. Another distinguishing mark of the present species is the less average depth of the black subterminal bar on the tail of the adult male. In habits it somewhat resembles our common kestrel, especially in the habit which has gained for the latter the name of "windhover." In flight it is very rapid, almost equalling that of a pigeon. It is particularly destructive to poultry, and the specimen sent me was killed in the act of carrying off a young turkey. Its food otherwise consists of mice and small birds, and Gibson has known it to feed on locusts in Buenos Ayres. It is resident at Tala, though migratory in the Argentine Republic.

Clutch of three eggs, taken 15th November 1880, from an old nest of the green parroquet (*Bolborhynchus monachus*), situated in a lofty Tala tree, about 15 feet from the ground. The largest of these measures $1\frac{17}{40} \times 1\frac{4}{40}$ inch, the smallest $1\frac{14}{40} \times 1\frac{4}{40}$ inch. They are nearly spherical in shape, and in colour are lighter than those of the common kestrel, and more resemble those of the lesser kestrel (*T. cenchris*). One of *T. sparverius* is figured in the *Ibis*, 1859, Pl. xii., Fig. 7.

This hawk builds no nest, but lays in the old or deserted one of some other species.

26. *Progne chalybea* (Gm.).—This species is known to the natives, in common with the other swallows, as "Golondrino." It is found throughout South America, from the Argentine

Republic northwards as far as Mexico. It frequents country districts and populous towns, as Buenos Ayres, alike. It is very like the purple martin (*P. purpurea*), but differs in the hue of the under plumage and also in its breeding habits. It is familiar, noisy, and, in the season of courtship, pugnacious. Its cry on approaching the nest, off which it flies at once, is loud and startled, but at other times they have a rather sweet and pleasing song, which, after the breeding season is over, they often sit and utter in a low tone on the top of an Ombu tree or a telegraph wire. They are fond of sailing in circles, particularly in a high wind. They arrive at Tala in October, and leave in April.

Clutch of four eggs, taken 7th November 1880, from a nest placed under the eaves of a shed at Tala, the largest of which measures $\frac{38}{40} \times \frac{26}{40}$ inch, the smallest $\frac{36}{40} \times \frac{27}{40}$ inch. They are of a pyriform shape, and pure white colour; occasionally five eggs are laid.

The nest is generally placed in chinks in walls or under the eaves, and sometimes, as found by Bartlett in Peru, in holes in trees. When the entrance to the hole is too large, it sometimes closes it so far with mud and straw. The lining of the above nest, and which was sent with the eggs, consists of paca, a sort of grass. Sometimes lichens are used for the purpose. It generally resorts to the same breeding places annually.

27. *Chlorostilbon splendidus* (Viell.)—native name "Picaflor."—This the only species of humming-bird found at Tala seems to be confined to Bolivia, Southern Brazil, the Argentine Republic, and Uruguay. Although possessing somewhat of the beautiful metallic lustre common to the family, it may be said to be rather unassuming in plumage. They are generally found near flowers, on whose sweets they live. In the Argentine Republic they feed greatly on those of the ceiba tree. Durnford mentions having found fragments of minute *coleoptera* in the stomach of one which he had dissected. They are common at Tala, and migratory, arriving in September and leaving in April, although a stray specimen has been observed in winter. They are said to have a sweet little song when hovering over the flowers to which they

resort. They are occasionally tamed as pets, and my correspondent saw a pair in a cage at Monte Video.

Clutch of two eggs, taken 20th November 1880, from a nest placed inside of a shed in Tala garden. Another, also of two eggs, taken in same shed on 11th December 1880. These are all of the same dimensions, viz., $\frac{20}{40} \times \frac{12}{40}$ inch, of an elongated ovate shape and pure white colour.

Both of the above nests were sent along with the eggs. The first of these is a beautiful little structure, formed of a few straws, lichens, and a material resembling palm fibre and lined with a white cottony substance, possibly the catkins of some plant. It is $1\frac{1}{2}$ inch in external diameter, 1 inch across the cavity, and $\frac{5}{8}$ of an inch deep. The second nest, although alike in size and shape, differs in wanting the white lining and in containing some fine grass and hair in its composition. The nest is, as in the above instances, sometimes built in sheds and sometimes in trees. In the latter case it is not placed above but suspended below a branch. Sometimes it is placed low, at other times at some height above the ground, and great care seems to be taken to assimilate the colour of the materials to the situation the nest is to occupy. They "hum" while engaged in building.

28. *Synallaxis striaticeps* (Lafr. et d'Orb.).—The name of "Ratonero," or little mouse, is applied to this species in common with some others, probably from their retiring habits. It is found in Bolivia, the Argentine Republic, Uruguay, and on the Rio Negro of Patagonia, where, however, it is rare. It frequents the neighbourhood of water, and seems to resemble in habits our sedge warbler. It is figured, as well as its egg, in the work of D'Orbigny, who observed it at a level of about 6500 feet above the sea. It feeds on small insects, and is of solitary habits, frequenting thick bushes. It is not a common species at Tala.

Two eggs, taken 10th November 1880, from a nest placed in a low bush, probably an incomplete clutch, other species of this genus generally laying four or five eggs. They measure $\frac{31}{40} \times \frac{24}{40}$ inch, and are in shape of a pointed oval, and in colour of a creamy white.

The nest is a curious structure, formed entirely of a grey

fibrous lichen, not unlike that occasionally found in the Scottish Highlands growing on very old birch trees. It is lined with a few feathers, and was found in a wood near Tala.

29. *Troglodytes furvus* (Gm.)—native name "Ratoncito," another form of the diminutive term for a mouse.—This is a noisy, restless bird, somewhat resembling our common wren in appearance, as well as in its song and actions, although not so retiring in its habits. It occurs from Nicaragua down through South America to Patagonia, where it was observed by Durnford. It has usually an angry harsh note, but has also a rather pleasing song, which it pours forth from the top of a bush, an aloe leaf, or even the top of a house. It is familiar and fearless, and comes into houses. Gibson narrates, that on one occasion he was sitting reading in the house, when one entered by the window, and actually alighted on the book he was reading, and rested there for a few seconds.

Clutch of three eggs, taken 20th November 1880, from a nest placed in the thatch of a house. Another clutch of three eggs, taken from a similar situation 11th December 1881. These average $\frac{28}{40} \times \frac{21}{40}$ inch in size, the largest being $\frac{30}{40} \times \frac{22}{40}$ inch, the smallest $\frac{26}{40} \times \frac{21}{40}$ inch. They vary much in markings as in size. The ground colour is white, which is minutely freckled with pinkish red spots, with a few lilac ones. Sometimes the spots are confluent towards the large end forming a zone, the markings running into each other. The shape is a somewhat round oval. The nest is placed in various situations, sometimes in a hole in a tree, when, if the hole is large, some twigs are used, but situations are often chosen like those adopted by the blue titmouse, such as the roof of a barn, the rose of a watering can, the sleeve of an old coat, or, as in this instance, under the thatch of a house. Its breeding season varies from the 20th October to the middle of January. The nest sent with the first-mentioned clutch of eggs is formed chiefly of horse hair and a few roots, and plentifully lined with feathers of the domestic fowl.

30. *Anthus correndera* (Viell.)—native name "Chachila." —This species is, like the last, widely distributed throughout South America, from New Granada to the Straits of Magellan, and it is also found in the Falkland Islands. It is very like

our common meadow pipit, indeed Latham considers it a variety of that species. It is found both in marshy and dry ground. They sing in the air, ascending nearly vertically, and again like our pipit descending with outspread wings. They are so tame as often to be struck down by the whips of the rough native carters. They vary in shade of colour apparently according to the sort of soil on which they are found. They are plentiful at Tala, and do not migrate.

Clutch of three eggs, taken 1st November 1880. Another of four eggs, taken 23d October 1881, both from nests placed on the ground. They measure from $\frac{31}{40} \times \frac{24}{40}$ inch to $\frac{30}{40} \times \frac{23}{40}$ inch. In shape and size they are very similar to those of the meadow pipit. The ground colour is white, and they are spotted more or less with olive brown or reddish brown, sometimes minutely, at other times the markings are bolder.

The nest is not so neatly formed as that of the meadow pipit, and more resembles that of a lark, the grasses of which it is formed being coarse and loosely put together.

31. *Serpophaga subcristata* (Viell.).—This species of fly-catcher is found in Brazil, Bolivia, the Argentine Republic, and other States bordering upon the River Plata. It is not very common at Tala, but remains throughout the year. Retiring in habits, it is also wanting in vocal power, having no song. Its food consists chiefly of insects, which it picks off the bark of trees as it runs up their sides. It occasionally goes in company with *Sycalis arvensis.*

Clutch of two eggs, taken on 20th November 1880, from a nest placed in a tree. Another clutch, taken 29th November 1881, from a nest placed in a bush in Tala garden. The eggs of the former measure each $\frac{24}{40} \times \frac{18}{40}$ inch, the latter $\frac{23}{40} \times \frac{18}{40}$ inch. They are of a very light buff colour, without markings, and are of a pyriform shape.

The nest is a remarkably neat and beautiful little structure formed of wool, lichens and hair, felted together, with a few fine roots which also serve to stiffen it, and it is lined with soft feathers. It somewhat resembles a miniature chaffinch's. It measures $2\frac{1}{2}$ inches across the top over all, and $1\frac{1}{2}$ inch across the cavity, which is $1\frac{1}{4}$ inch deep.

32. *Pyrocephalus rubineus* (Bodd.)—native name "Chur-

rinche," also "Brasa de fuego" (coal of fire); in Colombia it is called Sangre de toro (bull's blood), and in the Argentine Republic "militario" (soldier).—All these names have reference to the bright and brilliant plumage of this bird, which is said to catch the eye at a distance of 100 yards. It is found throughout South America except in the extreme south; it occurs in the island of Trinidad; and a sub-species is found in Mexico. It is common at Tala in summer. Its flight is rapid and short, and in habits it resembles our spotted flycatcher. Its song is sweet, and is often heard at night. Its food consists of insects. It is migratory at Tala, arriving in October. The old ones leave in January so soon as the young are able to feed themselves, but the latter nearly three months later.

Clutch of three eggs, taken 14th December 1880, from a nest in a tree. Another also of three eggs, taken 16th November 1881, from a nest placed in the garden hedge at Tala, 3 feet off the ground. These, with other eggs from the same locality, average in size $\frac{27}{40} \times \frac{20}{40}$ inch, the largest measuring $\frac{28}{40} \times \frac{20}{40}$ inch, the smallest $\frac{25}{40} \times \frac{19}{40}$ inch. They are of a brownish buff colour, strongly marked with a zone of dark brown spots near the large end, and they have been well likened to heavily spotted miniatures of the eggs of the common tern. Their shape is a round oval.

The nest is neatly built, is formed of much the same materials as that of *Serpophaga subcristata*, and is beautifully felted. It contains a good deal of horse hair, and is lined with feathers. The specimen sent measures $2\frac{3}{4}$ inches across the top, and 2 inches across the cavity, which is $1\frac{1}{8}$ inch deep. The female is the sole builder of the nest. Though seldom more than 4 or 5 feet off the ground, and usually built in exposed situations, it is difficult to find, from the bird's skill in harmonising it in colour with its surroundings.

33. *Tyrannus melancholicus*, Viell.—This flycatcher is found throughout South America, from Colombia and Venezuela as far south as the Argentine Republic. It also occurs in Honduras, and the West India Islands of Trinidad and Grenada. In Colombia it has been found at an altitude of 9000 feet. At Tala it is resident but not plentiful. It is found alike in the woods and gardens, in the latter of which

it is occasionally destructive to the seed beds. It is rather solitary in habits, and is fond of perching alone on tree tops, hence no doubt the name *melancholicus.* It frequents the neighbourhood of houses in winter, picking up any morsels which may come in its way. Its food consists otherwise of insects and seeds.

Clutch of two eggs, taken 29th November 1880, from a nest placed on the ground. These measure respectively $\frac{37}{40} \times \frac{26}{40}$ inch and $\frac{36}{40} \times \frac{27}{40}$ inch. The egg is of an elongated oval, with a white ground streaked longitudinally with brown and greyish lilac markings. It is figured in the *Ibis*, 1859, Pl. v., page 121. The nest is usually placed in a low fork of a tree, but in this case it was on the ground. It is formed of coarse grasses, roots, or vine tendrils, and a few pellets of wool, and is lined with fine grasses and horse hair. It measures four inches in external diameter, $2\frac{1}{2}$ inches across the cavity, and $1\frac{1}{2}$ inch in depth.

34. *Sycalis arvensis* (Kittl.) — native name "Canaria."— This finch is found from Colombia to Chili and the Argentine Republic. It goes much in flocks in the open in the campo or plains, but after the breeding season is over it often sits in trees all day singing and twittering. It lives, like other finches, chiefly on seeds. At Tala it is migratory, arriving in October and leaving in March.

Clutch of five eggs, taken 29th November 1880. Another of four eggs, taken on same date. These vary in size from $\frac{30}{40} \times \frac{21}{40}$ inch to $\frac{25}{40} \times \frac{20}{40}$ inch. They are white, of a bluish tinge, and spotted chiefly towards the large end with small reddish brown and a few lilac markings.

The nest sent is formed of old withered grasses, lined with finer material of the same nature; it measures $2\frac{1}{2}$ inches across the shallow cavity. It was as usual placed on the ground.

35. *Bolborhynchus monachus* (Bodd.)—native name "La-toro."—This the only species of Parroquet found at Tala is also found in Brazil, the Argentine Republic, and the other States on the River Plata. It is numerous at Tala, but is not found in such enormous flocks as Gibson describes in the Argentine Republic, where it is very destructive to fruit and

where the woods abound with its large nests. It affords excellent eating. It is a very noisy bird, but in captivity becomes quite tame and can be taught to speak. Dr Christison tells me that Doña Firminia, wife of one of the native Peons, had one whose language, although generally unfit for polite society, was often made use of in a singularly appropriate manner. Once when an eagle was hovering over him, he looked up at it with cool contempt, confident in the presence of his mistress, and exclaimed, "Puta che pario," or, "Your mother is no better than she should be." Although not imagining for a moment that the bird knew the meaning of the words, Dr Christison thinks it not improbable that he knew it to be a term of reproach. He was fond of chasing the dogs away by calling out "fuera, fuera," adding their name, and it is curious that he never mistook one dog for another. Mr Gibson related to me a curious occurrence which took place at his residence in the Argentine Republic, when a large cluster of their nests in the woods having been pulled down, an enormous flock of them appeared in the garden next day and broke over the whole of the young branches of the fruit trees, completely destroying all prospects of fruit for that year. If not an act of revenge on their part, it was certainly a curious coincidence. The species is stationary at Tala.

Clutch of three eggs, taken 14th November 1880, from a nest in a tree. These with eight in my collection from the Argentine Republic are in average measurement $1\frac{4}{40} \times \frac{32}{40}$ inch, the largest which is from the latter locality measuring $1\frac{8}{40} \times \frac{32}{40}$ inch, the smallest being from Tala and measuring $1\frac{3}{40} \times \frac{33}{40}$ inch. They are of a dull white colour and pointed at each end, somewhat resembling the egg of the grebe in this particular. Seven or eight eggs is a not uncommon clutch.

The nests are large structures suspended and woven into the extremity of the branches of trees about ten to fifteen feet off the ground. They are formed of sticks and thorny twigs, and every year the birds add to their size. They are usually placed in the woods at a distance from houses, and three or four or sometimes a dozen pairs frequent one series of nests. Each division of the nest occupied by a pair con-

sists of two chambers, with the entrance usually underneath. The nests are frequented all the year. Although not generally using other than the above-named materials, occasionally they are not particular, as the following will show. Two children of a native Peon having died were put in coffins, and as is the strange custom among that race, were laid on the ground at the foot of a tree in a wood. At the end of a year the father went in company with a son of my collector to place the bones in a small box for final interment. In doing this he quite unconcernedly cut off some pieces of skin and flesh which remained on the bones and cast them aside. The boy happening to pass the same place some time afterwards, found a parroquet's nest built in the tree above the spot, to which he ascended, when to his horror he found the birds had picked up the pieces of flesh and skin and incorporated them into the nest. He very speedily descended and did not go that way again for many a day.

36. *Chrysoptilus cristatus* (Viell.)—native name "Carpintero."—This term, meaning "Carpenter," is applied both to this species the red-headed woodpecker, and to the next. The present one is distributed throughout Southern Brazil and the States on the River Plata. It is not very plentiful at Tala, but is resident all the year. It goes in pairs, and perches not unfrequently on the top of a bush or tree, but their usual attitude is that of a woodpecker, and their food is also similar to that of other members of the family, being chiefly the insects they obtain on the trunks and branches of trees. They are noisy, fly low without moving their wings, and with an undulatory motion.

Clutch of four eggs, taken 28th October 1880, from a hole in a tree. Another, also of four eggs, taken 11th December 1881, from a hole in a wire fence post. These average in size $1\frac{5}{40} \times \frac{36}{40}$ inch, the largest measuring $1\frac{8}{40} \times \frac{38}{40}$ inch, the smallest $1\frac{2}{40} \times \frac{35}{40}$ inch. They are of an elongated oval shape, are pure white in colour, and have the highly polished surface common to the eggs of the family.

The nest is formed in a tree and sometimes in a post. It is excavated by the bird, and is generally nearly a foot in depth; the chips fall down inside and form the only lining.

They do not take long to the work of making the nest. My collector informs me that he watched a pair so engaged; on the third day only the tail of the bird was to be seen when at work, while on the fifth day it was out of sight. One of the birds is always on the watch while the other is sitting, and on the approach of an intruder gives the alarm, when they both fly off. Snakes often enter the holes, which renders an examination somewhat perilous : they eat the eggs.

37. *Colaptes agricola,* Malh. — the black-headed woodpecker, as above mentioned, is also known by the name of "Carpintero." It is more numerous at Tala than the last species, and like it is resident. Its range seems nearly coextensive with the other. Gibson does not mention it, but Lee found it common at Frayle Muerto, between the towns of Cordova and Rosario in the Argentine Republic. Its habits are very similar to those of the red-headed woodpecker. Occasionally it is seen in parties of two or three on the grass.

Clutch of four eggs, taken 26th November 1880, from a hole in a decayed tree. Another of four eggs, taken 27th October 1881, from a hole in a fence post. The average size of these is $1\frac{6}{40} \times \frac{36}{40}$ inch, the largest being $1\frac{7}{40} \times \frac{35}{40}$ inch. They are very similar to those of the last species, but are not so transparent, and are blunter at the small end.

The nest is placed in similar situations to that of the last, and the same remarks are therefore applicable to it.

38. *Guira piririgua* (Viell.).—The Guira cuckoo, native name "Perencho," is found throughout Brazil and the River Plata States. It is not uncommon at Tala. From its scanty covering of feathers it is a curious bird in appearance. It is gregarious, and has a curious habit of perching in flocks on a branch in a row facing different ways in exactly alternate order. Its cry is a harsh scream, but it is said also to have a musical note, which is seldom heard. Its food consists of grasshoppers, worms, small frogs, snails, and pieces of meat. Its flight is slow and feeble, and its tail is much in its way when alighting, causing it often nearly to perform a somersault involuntarily. It is not shy, and ventures among farm buildings, but its usual habitat is the "monte," or woods. Gibson states that the natives allege it can be taught to speak.

Clutch of three eggs, taken 14th November 1881, from a nest in a small wood half a mile from Tala. Also other two clutches of three eggs each, taken on 8th December 1881, from nests in the same wood. These are perhaps the most beautiful of any of the eggs of South American birds, and their appearance is very peculiar. The ground colour is a pale blue, resembling the colour of the egg of the heron, and over this is a remarkable encrustation of a white calcareous substance, finely reticulated, and giving the egg the appearance of being covered with lace in relief. It is figured in Thienemann's "Fortflanzungsgesichte,"[1] Pl. xv., fig. 11. They average in size $1\frac{27}{40} \times 1\frac{6}{40}$ inch, the largest measuring $1\frac{28}{40} \times 1\frac{7}{40}$ inch, the smallest $1\frac{19}{40} \times 1\frac{1}{40}$ inch. They are of an elongated spherical form, and are three or four in number.

The nest is usually a large structure of sticks, generally built about 20 feet from the ground. Of the above, however, one of the last mentioned was placed so low as to be within reach from the ground. They were all three in Tala trees, and were lined with wool wrought into the interstices of the sticks. Gibson mentions finding a nest lined with green alder leaves. No specimen has been sent me, owing to their great bulk.

39. *Columba picazuro*, Temm.—This bird, which is about the size of our rock pigeon, is pretty common at Tala, where it is resident. It occurs also in Brazil, Southern Paraguay, and the Argentine Republic. At Tala they are wild, go in flocks, and are swift on the wing. Their food consists of seeds and tender young grasses, as lucerne. Gibson also mentions their visiting the killing-places to feed. At night they roost on the top of lofty trees. Their voice is pleasing.

Clutch of two eggs, taken 28th October 1880, from a nest placed in a tree. These are white, and resemble those of the woodpigeon. They differ considerably in size, one measuring $1\frac{23}{40} \times 1$ inch, the other $1\frac{17}{40} \times 1\frac{4}{40}$ inch. Others I have from Buenos Ayres vary quite as much in dimensions.

The nest is usually placed, about 15 feet from the ground, in a tree, and consists of a shallow platform of twigs, much resembling the nest of the woodpigeon. The eggs are visible through the nest.

[1] Leipzig, 1845-57.

V. *Note on the Structure of the Body-Wall in certain Earthworms.* By F. E. BEDDARD, Esq., M.A. (Oxon.), F.R.S.E., F.Z.S.

(Read 16th January 1884.)

Although up to the present but few of the numerous genera of earthworms have been histologically investigated, it appears, from what is known, that the structure of the body-wall varies considerably in detail in different types; all agree, however, in possessing an outer epidermis which secretes a thin chitinous cuticle, and two subjacent muscular layers, an external transverse and an internal longitudinal. The present note relates to the structure of the body-wall in the two genera, *Perionyx* and *Perichæta.*

In *Perionyx* the epidermis closely resembles that of the common earthworm; it is composed of a single layer of delicate elongated cells, among which may be distinguished a number of larger granular cells, connected with the exterior by a fine pore, which passes through the outer chitinous cuticle. The structure of the epidermis in the common earthworm has recently been carefully studied by Dr Horst[1] and Dr v. Mojsisovics,[2] and both these observers agree in stating that it is only vascular in the region of the clitellum. In *Perionyx,* on the contrary, the terminal branches of the blood system penetrate within the epidermis of the general body surface. With the exception of *Pleurochæta,* a new genus lately described by me,[3] this is the only example of the phenomenon among the Oligochæta, and it is not a little remarkable that a structural feature of such obvious physiological advantage should be present in one genus and absent in another, especially when we consider that there can be no great difference between various species of earthworms in mode of life and in their physiological needs. There can be no possible doubt that this intra-epidermic vascular plexus is entirely unrepresented in the common earthworm as well as in the two genera *Urochæta* and *Pontodrilus,* upon which

[1] Tijdschr. d. Nederlandsch. dierk. Ver., Deel iii., afl. 1.
[2] Sitzungber. Akad. Wiss. Wien, 1877.
[3] Trans. Roy. Soc., Edinb., vol. xxx., pt. 2.

M. Perrier has recently published two admirable and exhaustive memoirs,[1] inasmuch as there is no necessity for an injection to demonstrate its presence. If this were actually necessary, the difficulty of successfully injecting such small animals would naturally introduce abundant source of error, but as a matter of fact it is not in the least necessary, for if the animal be killed by immersion in spirit, the capillaries remain injected with their own blood, and are extremely conspicuous under the microscope as yellow-coloured branching tubes. In *Urochæta* Perrier does not figure or describe intra-epithelial capillaries, and in *Pontodrilus* he expressly states that the terminal ramifications of the vascular system are contained in the circular muscle-layer, beyond which they do not penetrate.

Although the first description of intra-epithelial capillaries in earthworms is contained in my own paper already quoted, the fact itself was not new, since Professor Lankester had previously pointed out that the epidermis of the leech is vascular; in this Annelid, moreover, the capillaries are accompanied by pigmentiferous connective tissue cells.[2] The epidermis of *Perionyx* agrees with that of the leech, and differs from that of all other earthworms in being pigmented, but the state of preservation of the specimen from which my sections were taken was not sufficiently good to enable me to decide whether the pigment was intrusive or simply contained within the epidermic cells themselves.

In *Lumbricus* the epidermis is separated from the subjacent layer by a thin elastic membrane, from which are given off a number of fine processes, which ramify between the individual fibres of the transverse muscular coat. In both *Perionyx* and *Perichæta* this elastic network is very highly developed, and the meshes of which it is composed are in most cases five or six times the diameter of the enclosed muscle fibrils, which are thus furnished with a very strong elastic sheath, comparable perhaps to the elastic sareolemma of the vertebrate muscular fibre. The longitudinal muscles are similarly sur-

[1] Arch. de Zool. Expér., t. iii. and t. ix.

[2] Mr A. G. Bourne has recently (Proc. Roy. Soc., 1883, No. 229) proved the presence of an epidermic plexus in all the Gnathobdellidæ.

rounded by a network which is, however, fine and delicate in *Perionyx*, and appears to be completely absent in *Perichæta*. The function of this elastic network is probably to assist in extending the fibres after contraction; this would account for its greater development in the outer transverse layer, since, in the longitudinal layer, the contractions of the muscles of one side of the body would be alone quite sufficient to extend those of the opposite side. In the transverse layer there is of course no such direct counteracting mechanism, though no doubt the pressure of the perivisceral fluid materially assists in extending the contracted fibres. The elasticity of this intermuscular network must be at least an additional mechanical advantage.

This structural peculiarity of the muscular layers is not found in all Oligochæta. In *Urochæta* there appears to be no trace of it whatever. Transverse sections of the body-wall are figured by Perrier in his memoir on the anatomy of the genus, and show plainly that the individual muscular fibres are in close contact and not isolated from each other by any septa of elastic tissue; in *Pontodrilus* the circular layer of muscles resembles that of *Urochæta*, but the inner longitudinal muscles are separated into numerous bundles by elastic septa. Finally, in the genus *Pleurochæta* I have described a structure closely similar to that of *Perionyx* and *Perichæta*.

VI. *Notes on the Genus* Gyracanthus (*Agassiz*). By Dr R. H. Traquair, F.R.S.

(Read 19th December 1883.)

1. *Did* Gyracanthus *possess dorsal spines?*

Although Agassiz himself pointed out that the spines of *Gyracanthus* were not bilaterally symmetrical, inasmuch as one side was more rounded than the other, he nevertheless regarded them as dorsal, and so did people in general, until in 1863 Messrs Kirkby and Atthey pointed out the probable pectoral nature of some at least of these appendages, the grounds for this conclusion being the conspicuous lateral cur-

vature shown by such specimens, along with the wearing away of the apices, as if they had been subject to habitual attrition at the bottom of the water in which their possessors lived. In 1868 Messrs Hancock and Atthey returned to the subject,[1] and, reviewing the extensive series of specimens in the collection of the last-named gentleman, divided them into two categories—first, those with lateral curvature and worn apices, and second, those in which apparently there was only an antero-posterior curvature and in which the apex was entire and pointed. The former set, which could also be arranged in pairs, they regarded as *pectoral,* the latter as *dorsal.*[2]

The occurrence of numerous spines of this genus in the Blackband Ironstone of Borough Lee, near Edinburgh, having lately induced me to inquire into the whole subject of *Gyracanthus,* I was surprised to find that, among the numerous specimens which came under my observation from that and other localities in Scotland, there was not one which was bilaterally symmetrical, and which consequently could be assigned to a median position. On this subject I published a few remarks in the *Geological Magazine* for December 1882. To pursue the subject further it was, however, abso-

[1] Ann. & Mag. Nat. Hist. (4), 1868, vol. i., p. 368. In a footnote Messrs Hancock and Atthey refer to a paper by Messrs Atthey and Kirkby, entitled "Fish-remains in the Coal-measures of Durham and Northumberland," as having been read before the British Association at Newcastle in 1863, and as containing the first suggestion of the paired nature of these spines. I cannot find this paper in the British Association's *Proceedings* for that year; and although a paper of the same title is found in the *Proceedings* of the Tyneside Naturalists' Field Club, it contains no reference to *Gyracanthus.* These original remarks would therefore seem not to have been published.

[2] In a paper on *Tristychius,* published in the Ann. & Mag. Nat. Hist. for September 1883, Mr. T. Stock states, with regard to Messrs Hancock and Atthey's views as to the pectoral nature of certain *Gyracanthus*-spines, that he has "been able to confirm their conclusions by the finding of an interesting specimen containing well-preserved remains of the pectoral arch," and refers to a paper on the subject, read by himself to the Edinburgh Naturalists' Field Club. However, on consulting the paper, now published (Trans. Edinb. Nat. Field Club, vol. i., pt. 2, pp. 50, 51), it turns out that the "pectoral arch," in this case, is Messrs Hancock and Atthey's "carpal bone," of which more anon.

lutely necessary to re-examine the specimens in the Atthey Collection, now in the museum at Newcastle-on-Tyne. And having recently visited that city, I must here express my cordial thanks to my friends Mr W. Dinning, Secretary of the Newcastle Natural-History Society, Mr R. Howse, Curator of the Museum, and Mr J. Hancock, member of committee, for the kind and liberal manner in which they afforded me every facility for examining the specimens in that remarkable collection of Coal-measure vertebrate remains.

Although I have not seen the original type of Agassiz's *Gyracanthus tuberculatus*, I have no hesitation in referring to it the great majority of the specimens from Newsham in the Atthey Collection, and they form, indeed, a most beautiful and instructive series. And as no systematic description has been given of this form since the time of Agassiz, who had only a drawing of a mere fragment to go upon, it will not be out of place to enter somewhat into detail as to the configuration of these spines.

Proceeding first to the consideration of those labelled "pectoral" in the Atthey Collection, one very fine example is 15¼ inches in length by 2¼ in diameter at its widest part near the base; its distal extremity is obliquely truncated or worn off on the anterior aspect, and the whole spine, when looked at from the front, displays a well-marked lateral curvature or bend, which enables us to distinguish a convex and a concave side. It will also be observed that the lateral surface is more gibbous or rounded on the convex aspect of the spine, flatter on the opposite, so that for purposes of description we may distinguish the two sides as "gibbous" and "subgibbous" respectively. Still, regarding it from the front, it will be seen that the sculptured surface ends proximally in an acute angle; but the apparent middle line on which the tuberculated or "gyrating" ridges meet *does not bisect* this angle, but divides it so that the sculptured part is larger on the gibbous side. Now, turning the spine over so as to look at it from behind, we observe that the longitudinal cleft or sulcus leading into the central cavity is not in the middle of the non-sculptured inserted part, but is placed more towards the subgibbous side, so that we have here from the very beginning a marked

deviation from bilateral symmetry, one side, the convex or gibbous one, being larger than the other. We next observe that, from the distal closure of the sulcus, the lip on its subgibbous side is continued onwards towards the apex as a blunt keel or margin, having on the gibbous side a shallow longitudinal depression or groove. Thus the spine has now become keeled or marginated posteriorly, and from this margin round to the line of convergence of the gyrating ridges in front the surface on the subgibbous side is narrower and flatter, while on the opposite or gibbous aspect it is more extensive, more rounded, and provided with the aforesaid longitudinal groove. I have already, on a previous occasion,[1] pointed out that the groove is obviously equivalent to the posterior flattened area in such median spines as *Ctenacanthus*, but here turned *awry* and looking to one side, while the posterior marginal ridge represents one of the denticulated margins in the last-named genus; the other is to be looked for in the opposite or feebly-marked edge of the groove on the gibbous side in *Gyracanthus*. The sculptured or gyrating ridges are on the whole pretty straight and parallel in their course, though they show a slight tendency to a sigmoidal direction, curving a little towards the apex in front, towards the base behind, as well as increasing progressively in obliquity from the base onwards. They are closely tuberculated along their whole extent, and are continued as lines of tubercles over the lips of the posterior groove, in the bottom of which they converge and meet. In the above described specimen the groove is filled with tubercles as far as the spine reaches; but in others the groove becomes bare of tubercles at a variable distance from the closure of the sulcus, and only marked by delicate longitudinal striæ, while in one I find it devoid of tubercles along its whole extent. In some too, before the truncation of the apex occurs, the gyrating ridges tend to lose their close tuberculation, at least posteriorly, and to become only distantly nodulose or even quite plain.

Putting the wearing of the tips altogether aside as a secondary question, the striking want of bilateral symmetry in these spines, together with their occurrence in "rights and

[1] Geol. Mag., dec. ii., vol. ix. (1882), p. 542.

lefts," amply justifies the opinion of Messrs Kirkby, Atthey, and Hancock that they were pectoral or at least paired appendages. Which are the right and which the left spines, it is, however, at present not very easy to determine. Accepting the sulcated aspect as posterior, it would be necessary to ascertain whether the flat or the gibbous side was superior in order to indicate to which side of the fish it belonged.

Now, turning to the spines labelled "dorsal" in the same collection, we find that they are smaller in size, varying in length from 4½ to 10½ inches, and almost all lying laterally compressed on pieces of shale. In this way the lateral curvature is obscured, though in one, also marked "dorsal," which happens to be only obliquely placed on its matrix, this curvature is quite obvious. Furthermore, all of them show in other respects the same want of lateral symmetry which I have just described in those acknowledged to be pectoral, namely, the possession of a flat and of an inflated and grooved side; in fact they are rendered still more asymmetrical than the large truncated spines by the much greater prominence and sharpness of the posterior marginal keel, which we have seen is morphologically a lateral structure in the general plan of the spines. This keel is also furnished with a row of small closely-set recurved denticles. The gyrating ridges become very oblique towards the point, and tend to become plain or only distantly nodulose, except perhaps on the front of the spine. On the flat side a space bare of ridges runs down from the point along the posterior margin for about 1½ inch, and an analogous appearance is also observable on the grooved side. The groove itself is smooth and marked with delicate longitudinal striæ; and, as Messrs Hancock and Atthey have already noted, the point is much compressed laterally.[1]

If we next compare the proximal or basal end of one of the largest of these supposed dorsal spines with the distal extre-

[1] These young spines of *G. tuberculatus* bear an extreme resemblance to the figure of *G. denticulatus* (Davis), in Ann. & Mag. Nat. Hist. (5), vi., 1880, p. 373, being similar in shape, in the characters of the gyrating ridges, and the denticulation of the posterior margin, while the same bare space runs down for a little distance from the point. Mr Davis, however, states that his spine has *two* rows of denticles posteriorly.

mity of one of the least worn of those labelled "pectoral," we find a mutual approximation in character; and, further, if we compare both with an allied species, *G. nobilis* (Traq.), from the Edinburgh district, pretty large specimens of which sometimes occur with the points very slightly worn indeed, the whole matter is cleared up. I have now no longer any doubt that the spines of *Gyracanthus tuberculatus*, supposed by Messrs Hancock and Atthey to be "dorsal," are simply young specimens of the very same spines classed by them as "pectoral," and represent the distal portions or extremities, which in the adult spines have been lost by attrition. These spines increased by progressive growth at the base, and as they grew, progressive differences in sculpture, amount of lateral compression, and so on manifested themselves; so that the young spine is not a miniature of the old one, but represents only a distally situated portion of it, greater or less as the case may be. And in the case of the Newsham specimens of *Gyracanthus tuberculatus*, I may mention, as a final and convincing proof, that, although Messrs Hancock and Atthey state that in the spines supposed by them to be dorsal the pointed extremities "are all perfect, not being in the least worn," I find in one so labelled, a specimen 11 inches in length, very distinct wearing already in progress just in front of the tip.

Although Messrs Hancock and Atthey's dorsal spines of *Gyracanthus* are certainly not so, and although, since my attention was directed to the subject, I have not been able to find in any collection, public or private, spines of this genus to which I could assign a median position, and am consequently inclined to doubt the presence of dorsal spines altogether, I do not mean to affirm that the subject is thereby closed. Further investigation is necessary into the Irish Lower Carboniferous *G. obliquus* of M'Coy,[1] and into two American species named *G. compressus*[2] and *G. Alleni*[3] by Prof. Newberry, the published figures of which do not indicate

[1] Palæozoic Fossils, p. 629, pl. iii. *k*, figs. 13, 14.
[2] Pal. Ohio, vol. i., p. 330, pl. xxxvii., figs. 1, 2.
[3] *Ibid.*, p. 331, pl. xxxvii., fig. 3.

a want of lateral symmetry. M'Coy gives an outline of the transverse section of *G. obliquus* from a position considerably proximal to the point, in which the two sides with the posterior area seem as symmetrical as in *Ctenacanthus*. In such a spine it would be well to examine the extreme point. There is in the collection of the Geological Survey of Scotland a rather young spine from the Liddesdale beds, which I am inclined to refer to *G. obliquus*, and in it near the tip, the transverse section has a form much resembling in general characters that in M'Coy's figure; but one margin of the groove is nevertheless a little more prominent than the other. It is to be hoped that American palæichthyologists will carefully examine the spines of *Gyracanthus* occurring in their country with special reference to the present question.

2. *The supposed Carpal Bones of* Gyracanthus.

Of constant occurrence in the same beds with *Gyracanthus*-spines, and often found closely associated with them on the same slabs of stone, are certain peculiar bones, first noticed by Messrs Hancock and Atthey, and by them interpreted as "carpal" bones. These occur of two forms or shapes, the first of which was described by the above-named authors in 1868.[1] It is a flat triangular bone, with a thick apex opposite to a thin base; and two other sides, one of which, the longer, is slightly convex, the other, or shorter, being straight or slightly concave: of the two surfaces one is slightly convex, the other slightly concave in general contour. Of these Messrs Hancock and Atthey say, "Their structure is very open; and as they are seldom well preserved, they are probably only imperfectly ossified; the bony fibre radiates from the apex to the expanded base. There can be little doubt that these are carpal bones similar to those in connexion with the pectoral fins in sharks and dog-fishes."

The second form is briefly noticed by the same authors in another communication published four years later, and its form is described as follows:—"This second form is probably the inner carpal; it is a broad flat bone irregularly bilobed or

[1] Ann. & Mag. Nat. Hist., ser. 4, 1868, vol. i., p. 369.

somewhat reniform, with one of the lobes produced and the external margin straightened; the convex border is a little flattened, angulated, and thickened, thence the bony fibres radiate to the opposite or lobed margin. . . . The texture of the bone is quite similar to that of the large triangular carpal, namely, it is of a semicartilaginous appearance, with coarse radiating fibres extending from margin to margin."[1]

In other passages Messrs Hancock and Atthey clearly indicate that they considered the thin margin, in both forms, to be distal, and the apex, or point from which the "bony fibres" radiate, to be proximal in original position.

Before making any critical remarks on the above determination of the bones in question, it is necessary to fix accurately to what elements of the Selachian skeleton Messrs Hancock and Atthey compare them.

The term "carpal" is not used by anatomists of the modern school to denote any part of the skeleton of the fore limb in fishes; but on turning to Prof. Owen's "Comparative Anatomy of the Vertebrata," vol. i., p. 168, Fig. 104, we find the three basil cartilages of the pectoral fin of the picked dogfish so designated. Two of these, the *mesopterygium* and *metapterygium* of Gegenbaur, are triangular, with their apices directed towards the shoulder-girdle, while the third or *propterygium* has an oblong shape, faintly reminding us of the second form of so-called carpal of *Gyracanthus.* There can thus be no doubt that these basal cartilages, which, in the skeleton of the recent shark, intervene between the shoulder-girdle and the radial cartilages, or cartilaginous fin-rays, are the elements which Messrs Hancock and Atthey meant by the term carpal. And the question is simply this, is it likely that the process of calcification in such cartilages would give rise to bodies like the peculiar bones so often found associated with the spines of *Gyracanthus?* Or can any better explanation of their nature be suggested?

One point in their external configuration was not noticed by Messrs Hancock and Atthey, namely, that these bodies were hollow, and that their extreme flatness is due to the crushing together of the thin walls of the internal cavity. If

[1] Ann. & Mag. Nat. Hist., ser. 4, 1872, vol. ix., pp. 260, 261.

we take first one of the triangular series, it may easily be seen that the two walls, or laminæ of which the bone is composed, are united at the apex and along the two thick sides which meet at the apex, but that they are separate at the thin base, at which accordingly the cavity was open. It may also be seen that the edges of the basal opening do not coincide, as careful development of these edges shows that the one on the convex side of the bone is indented by a large angular notch or sinus, which runs up for some distance in the direction of the apex; this appearance I have seen in every case in which I have looked for it. The internal cavity is at once distinguishable, filled with matrix, when a specimen is broken or cut across. I have equally assured myself of the hollow character of the bones of the second series.

If we now look at the texture of these bodies we shall be at a loss to explain the expressions "imperfectly ossified" and "semicartilaginous," used by Messrs Hancock and Atthey in the passages already quoted. On examining the surface with a lens its apparent fibrous aspect is seen to be due to its being closely covered with minute grooves interspersed with small openings, these markings being clearly vascular in their nature and of the same essential character as those on the inserted portion of a Selachian spine, only not so regularly parallel as is usually the case in the latter. On making microscopic sections, transverse and longitudinal, through the substance of the supposed "carpal bone," it is found to be completely traversed by a close network of vascular or Haversian canals, the canals in some parts enlarging so as to give a rather more open character to the tissue than is found in the internal part of a *Gyracanthus*-spine itself, while the ground-substance, hard and calcareous, is permeated by minute branching and anastomosing tubules, which are frequently seen to radiate from the vascular canals. This is not, however, the structure which Selachian cartilage assumes when calcified or "ossified";[1] on the contrary, if the tissue be not vascular dentine, it is certainly very like it.

[1] For an account of the structure of calcified Selachian cartilage, see Williamson on the "Structure and Development of the Scales and Bones of Fishes" (Phil. Trans., 1851).

I am therefore of opinion, that the bodies in question have nothing to do with "carpal bones," or with the endoskeleton of a shark at all, but that they were, on the other hand, dermal appendages, which may probably enough have been situated in the neighbourhood of the pectoral fin, the thin or open side being proximal and the apex distal. The want of enamel, or of sculpture on any part of the surface, shows that they must have been covered with a thin layer of skin. Their frequent occurrence in close relation to the spines of *Gyracanthus* renders it, indeed, highly probable that they belong to the same fish.

I hope, on a future occasion, to enter more minutely into the microscopic structure, both of these bodies, and of the *Gyracanthus*-spines themselves.

3. *On two new Species of* Gyracanthus.

In the *Geological Magazine* for last month (Nov. 1883) I have given brief diagnoses of two new species of this genus from the Carboniferous Limestone series of Scotland, concerning which I propose, in the present communication, to enter a little more into detail.

Gyracanthus nobilis—Traquair.

Gyracanthus tuberculatus (Traq.), Geol. Mag., dec. ii., vol. viii., 1881, p. 34.
Gyracanthus nobilis (Traq.), *Ibid.*, dec. ii., vol. x., 1883, p. 542.

The spines which I have named *Gyracanthus nobilis* are of common occurrence in the ironstone worked at Borough Lee, near Edinburgh, belonging to the Middle Carboniferous Limestone series of Central Scotland; and I have also seen a fragment from a similar horizon at Cowdenbeath, in Fifeshire. At first I confounded them with *G. tuberculatus* (Ag.), but the accession of more extensive material, along with a closer investigation of the subject, soon convinced me of their specific distinctness.

Gyracanthus nobilis attains a large size. One spine in my own collection, wanting a small portion of the base, but having its extreme point preserved, measures 21 inches; had it been

entire, its length could not have been less than 2 feet. Another, wanting the point, must have been about the same size; and fragments are not uncommon which indicate still greater dimensions. The general form is elongated and slender, the breadth increasing more rapidly towards the base in adult specimens. They are very variable in respect of curvature: in some both antero-posterior and lateral curves are well marked; in others the lateral bend is only slight or hardly perceptible; and I have one which appears almost perfectly straight in doth directions. Every one of them, without exception, is nevertheless asymmetrical as regards those special points of configuration upon which I have dwelt in connection with *G. tuberculatus*, and, as in that species, they may be arranged in pairs.

In the form of the non-sculptured inserted part, with its posterior sulcus, and in the general configuration of the spine as seen in transverse sections, *G. nobilis* closely resembles *G. tuberculatus*. The posterior marginal keel is in its distal portion strongly denticulated; in one specimen the denticles may be traced, from the point, a distance of 10 inches in the direction of the base. The posterior groove varies much in its degree of sharpness; in some it is very shallow and slightly marked till towards the point, while in others it is very well defined along its whole extent. In adult specimens continuations of the gyrating ridges usually encroach upon it at its commencement; but the salient point in this species lies in the disposition and mode of tuberculation of these ridges. At the proximal end of the spine, in adult examples, they are disposed much as in *G. tuberculatus*, meet each other anteriorly at much the same angle, and are closely tuberculated along their whole extent. But near the closure of the sulcus this close tuberculation becomes limited to the anterior aspect, each ridge as it arises and advances forward showing first a comparatively distant tuberculation, then a smooth space (sometimes very minutely crenulated) on the side of the spine, and finally becoming thick and coarsely tuberculated as it turns round to the front. Where this feature of the ridges commences *they also become excessively oblique and very delicate*, and in some specimens they also occasionally bifur-

cate along the sides of the spine; but in front, where the tuberculation appears, *they become coarse and curve a little forward,* so as to become less oblique, and in many cases they turn slightly again towards the point just before meeting those of the opposite side. Towards the extremity the ridges become entirely smooth on the sides of the spine, their slight curvature also ceases, and the tuberculation of the anterior aspect gives way to simple undulation. The point, even where it is not positively truncated by attrition, looks smooth and rubbed.

Gyracanthus nobilis may easily be distinguished from both *G. formosus* and *G. tuberculatus* (probably only varieties of one common species) by the direction of the gyrating ridges. In the latter forms these ridges are disposed in a pretty straight and parallel fashion over the sides of the spine, although they do increase in obliquity towards the apex. Here, however, their excessive obliquity and delicacy along the sides, after the closure of the sulcus, give the sculpture a peculiar aspect which cannot be mistaken. The tuberculation of the ridges is in general coarser than in *G. tuberculatus,* and, in the latter, it is only pretty well towards the apex that the ridges tend proximately to become plain, or only distantly nodulose. Of course, as regards the disposition of tuberculation, this new species differs still more from *G. formosus,* in which the ridges from the very base tend to be plain in front.

Adult specimens of *G. tuberculatus* show invariably, so far as I have observed, a strongly-marked lateral curvature; in *G. nobilis,* as we have seen, its presence and amount is very variable.

The course of the ridges, the disposition of the tuberculation, and the form of the transverse section equally distinguish it from *G. obliquus* of M'Coy, and it is certainly not *G. denticulatus* of Davies. Nor can it be shown to be identifiable with any of the North American species named by Professor Newberry and Dr Dawson.

There only remains the *G. alnwicensis* of Agassiz, which is recorded from a somewhat similar horizon, viz., the Carboniferous Limestone series of Alnwick, in Northumberland. This is very briefly mentioned by Agassiz as being slender in

form, with very oblique and entirely smooth or non-tuberculated ridges, which ridges also bifurcate, and even trifurcate, in a very remarkable manner, as shown in the figure. If this description is correct,[1] *G. nobilis* is even more distinct from *G. alnwicensis* than from any other.

One remarkable feature in these spines as occurring at Borough Lee is the small amount of apical wearing to which they have for the most part been subjected. Even the extreme point, only a little blunted and polished, is sometimes present in large specimens, and in many others comparatively little of the extremity has been lost by that process which has reduced some of the large *Gyracanthus*-spines from Northumberland and Staffordshire to mere stumps. It has been noted that this wearing process has obliquely truncated the Northumbrian specimens in their anterior aspect; but in those from Borough Lee evidence of wearing is sometimes found on the posterior aspect as well. These circumstances would lead us to infer some difference either in the habitat or the habits of the species in question.

Gyracanthus Youngii—Traquair.

Gyracanthus Youngii (Traq.), Geol. Mag., dec. ii., vol. x., 1883, p. 543.

Occurring also at Borough Lee, but found likewise in many other localities on the horizon of the Scottish "Edge" Coal or Middle Carboniferous Limestone series, is a remarkably distinct species of *Gyracanthus*, to which I have given the name *G. Youngii*, in honour of my friend Mr John Young, of the Hunterian Museum, Glasgow, who has done so much for the elucidation of the palæontology of the west of Scotland. The finest specimens I have seen are in the collection of Mr R. Craig, Beath, Ayrshire, and are from the shale overlying the Clay-band Ironstone at Barkip, Dalry. I have

[1] Possibly it is not, as Agassiz never saw the specimen, but drew up his description from a drawing sent to him by Messrs Buckland and De la Beche. As reproduced in the plate in the "Poissons fossiles," this drawing looks like a very hurriedly executed pen-and-ink sketch, from which it is quite impossible to identify anything. Under these circumstances I doubt whether the term "*alnwicensis*" has any more value than a mere manuscript name.

also seen specimens from Bo'ness in Linlithgowshire (collection of Mr H. M. Cadell), Possil in Lanarkshire (collection of Mr John Young), Cowdenbeath in Fife, and Maryhill near Glasgow.

These are large spines, some of which must have attained a length of over 2 feet, had not their apices been worn off. They always show some amount of lateral curvature; but the degree to which they are antero-posteriorly bent is very variable; some are indeed in that direction nearly quite straight.

The first salient point which strikes the eye is the great size of the inserted or non-sculptured portion, which is not only broader and more expanded, but extends further beyond the sculptured part proximally than in any other species. The anterior middle line on which the gyrating ridges meet does not cut equally the very acute angle formed proximally by the sculptured part; but in this case the larger division is found on the subgibbous side, this being due to the encroachment of the non-sculptured part on the gibbous side. It is next to be noticed that the shaft of the spine after the closure of the sulcus is more cylindrical than in other species; still the want of bilateral symmetry is very obvious, and a gibbous and subgibbous side may be distinguished. The posterior groove is sometimes not apparent for some distance after the closure of the sulcus, or, though indicated, it may be filled with tubercles; sooner or later it becomes well marked, and the lip on the subgibbous side becomes more prominent than the other, but does not form so marked a feature in the configuration of the spine as the corresponding posterior marginal keel in such species as *G. tuberculatus* and *nobilis;* it is in fact only towards the extremity that the spine takes on a keeled appearance. A well-marked row of recurved denticles occurs along the aforesaid lip or ridge of the posterior groove on the subgibbous side, and on that of the opposite side denticles are also seen in some examples. The last remarkable feature in this species is the slight obliquity of the gyrating ridges, which meet each other on the front of the spine at angles greater than right angles almost as far as the very apex. These

ridges are also rather less oblique on the subgibbous than on the gibbous side; on the former they are in fact sometimes nearly transverse; a certain amount of sigmoidal curvature is assumed after the middle of the spine, the anterior extremities of the ridge turning slightly towards the apex, their posterior extremities towards the base. Only towards the apex have the ridges any marked obliquity in their middle portions, and there they often also become wavy. The gyrating ridges are closely tuberculated over their whole extent, except towards the apex, where the tuberculation tends to become irregular. The amount of apical wearing is very variable.

VII. *On the Occurrence of the Little Gull* (Larus minutus) *in the Island of North Uist; with Remarks on the Objects of the International Ornithologists' Congress at Vienna, and on Uniformity of Method in recording Rare Species in future.* By JOHN A. HARVIE-BROWN, Esq., F.R.S.E., F.Z.S., President.

(Read 19th December 1883.)

This rare British bird was shot upon the 1st of November last, by Mr John Macdonald, Sir John Campbell Orde's factor at Newton, North Uist. It was seen on the island of Bernera, Sound of Harris, the day before, and when shot in North Uist it was found to have one foot awanting.

The above are all the particulars I have been able to obtain regarding this specimen, which is evidently a young bird of the year, probably bred on the Russian lakes this past summer. It is obligingly lent for exhibition by Mr J. D. Dougal, gunmaker, Glasgow, to whom it had been sent for preservation, and to whom the Society's thanks are due for this opportunity of exhibition.

From already published accounts of the distribution of the species (*vide* Dresser's "Birds of Europe") it would appear that its usual lines of migration are as follows: Prior to 1866, very rare in Britain, though several obtained on the Nor-

thumberland coast, and seen on Farne Islands. In 1866, several obtained on the Yorkshire coast. In 1868, Mr J. H. Gurney, jun., obtained eight, also from the Yorkshire coast. Before 1870, most had occurred in October and November. In Scotland, of very rare occurrence. Localities—East Lothian, Wigtownshire, and Sutherlandshire since added. Formerly bred in Gottland, now extinct there; occasional in Denmark; and has occurred in Heligoland. Eastern in its range as far as Europe is concerned; only occasionally occurring on the Baltic and at the mouths of rivers in Germany during migration. Also included in a list of Livonian birds. Occasionally visits the Swiss lakes. Of rare occurrence in Holland, but small flocks at intervals observed on the coasts. A few pairs have been known to breed on the "Hook of Holland." Very uncertain in Flanders; a few killed at the mouth of the Scheldt and in the south of France. Not recorded from Spain. Common on the south coast of Sicily, and appears in spring on the Tiber. Common in the Bay of Catania. Some years plentiful in Malta. Accidentally in Algeria. Common in winter in the Ionian Islands. Numerous in Greece and Macedonia in spring. Breeds in Ladoga and Onega Lakes in Russia, and in the salt lakes of the south of Russia; and eastward to the Lena (Meddendorff). It was searched for in vain by Wolley in Öland in 1856. Said to have bred as far north as Archangel (Meves). Occurs in Transylvania in late spring.

From the above notes it would appear that the North Uist specimen is the farthest westerly record in Europe of the species. The Sutherland specimen is the most northerly in Britain, and the Wigtownshire one the most southerly in Scotland, the East Lothian and Berwickshire specimens being nearest to the northern verge of the migration of many continental species, which appears to be from Heligoland towards the entrance of the Firth of Forth or reaching as far north as Bell Rock and the Firth of Tay. Another route of migration is through the Pentland Firth, and while the Wigtownshire bird probably came *viâ* Heligoland and Firths of Forth and Clyde, this North Uist bird almost as certainly came *viâ* the Pentland Firth, and landed on the first likely-looking feeding

ground it met with on its course (*vide* "Migration Reports, General Remarks, especially 1882," pp. 53, 63, 69).

I have, I think, before this made the remark that in the event of any Ornithologist or sportsman shooting specimens and recording the occurrences of rare species of birds upon our coasts, or in any of our British Counties, not only should the date and locality of the specimens be carefully recorded and the latter described, but also—and this, now-a-days, is really the most important item in the connection—the state of the weather for the two or three or more days previous to its first appearance, and at the time of its capture, the force and direction of the wind—if possible both upper and lower currents—and the state of the birds' health, whether starved and thin, or plump and in good condition. The items could easily be noticed at the time, and if recorded would, before long, accumulate and greatly assist students of migration. Another point is that, when birds are so observed, it should be noted whether they appear to be pursuing a migration at the time, or whether they are resting or feeding, and whether solitary or in a flock; and the direction of flight, if actually on migration, should be carefully recorded, and also the age and sex of the specimens obtained.

I would like to impress the importance of recording these data upon our British Ornithologists, and others who obtain or record rarities in future. If such records had been kept, say since 1843 (the date of the publication of the 1st volume of the "Zoologist"), what an immense mass of really valuable matter would have been accumulated in the forty-two volumes of that periodical alone, not to speak of others of our Scientific Serials and *Proceedings* of Scientific Societies. I believe it would not be too much to say, that had this been done, and pursued upon an uniform and scientifically correct basis, the great mystery of migration would have been solved long ago. If, owing to want of experience hitherto, we have failed to record the most important points in connection with the occurrences of rare birds, at least let us not in future fail in this respect; and let any one who has a rare bird or butterfly or other insect foreign to our British Fauna to record, never after this forget that the record is *imperfect* unless accom-

panied by these particulars, so far as available; and of course the more minute and perfect these are, the better, and the sooner will they be likely to prove of scientific value.

Now, in order in some measure to supply the omission in the above record of the Little Gull, I have referred to our migration schedules for 1883.

At Dhuheartach on 29th October the wind was S.S.W. with haze, and wild geese were seen flying S.E., while stonechats and thrushes were flying round the lantern at 5 a.m., or resting on the rocks at 12 noon.

On the 31st October the wind had gone round to N.N.W., fresh with haze, when one woodcock—the first mentioned on the schedule since 8th April—was killed by striking the lantern; and a blackbird was seen "flying E." This is the latest scheduled record I have at present from this locality. I will merely remark here that this "flying E" or "flying S.E." is the normal direction of flight at Dhuheartach of birds on migration, as already shown in our reports.

Again, at MacArthur's Head, Islay, migration was proceeding on the 30th, and winds were from W. to S. with haze. On our East Coasts also prevailing winds were southerly and westerly, and a great migration took place at Isle of May during the last week in October.

From these parallel data we arrive at the conclusion that the Little Gull exhibited to-night had got into the groove or regular current of general migration of other species, and the wind being that particularly favourable to migrants to our coasts, as has been shown in our reports, it carried on with the stream. Being a young bird of the year upon its first migration, and having probably no older guide of its own species, or having been lost previously, perhaps, from a flock of its own species, it carried along with the other migrants beyond the usual limits of its autumnal range, and then rested on the sandy and marshy island of Bernera in the Sound of Harris, which, I know from personal observation, is the first spot on that line which is admirably adapted to the habits of the bird in question. It passed southward to North Uist, because it would not naturally fly

west over the sea, and, probably passing flocks of other migrants, indicated to it, even in its inexperience, the correct *old* lines of migration.

I have a paper now in preparation, in which I will much more fully discuss and, I think, satisfactorily prove some of the causes and reasons of migrational phenomena. I have said enough here, however, to make the record of this specimen somewhat more interesting than a bare mention of the fact of its occurrence, and I hope that in future all who record rare occurrences will see the importance of making their records complete, on the lines I have endeavoured to indicate.

One of the principal subjects for discussion at the Ornithological Congress, now being held at Vienna under the auspices of the Heir-Apparent Archduke Rodolphe, is, as stated in the programme of the Congress, the "institution of Ornithological Observation-Stations extending throughout the whole world inhabited."

In North America, already a large scheme has been set on foot for the purposes of working out the phenomena of migration. This is a Committee on Migration, under the auspices of the American Ornithologists' Union. All interested in this subject should pursue the programme and schedules issued by the said committee, and which are procurable from Dr C. Hart Merriam, Locust Grove, New York.

In our own country, as I think you are aware, the British Association appointed a committee in 1880 "for the purpose of obtaining (with the consent of the master and brethren of the Trinity House, and of the Commissioners of Northern Lights) observations on the Migration of Birds at Lighthouses and Lightships, and of reporting upon the same at York in 1881;" of which Mr John Cordeaux, Great Cotes, Ulceby, Lincolnshire, is appointed secretary. This committee has been re-appointed at each meeting of the British Association since that date, and has issued four reports for 1879, 1880, 1881, and 1882, and the report for 1883 is now in the press. These reports are obtainable from Messrs West, Newman, and Co., 54 Hatton Garden, London. Previous to these reports of the committee, Mr John Cordeaux had published

some accounts of the destruction of birds at lighthouses, and I myself endeavoured to collect land-data connected with the effects of the severe winter of 1878-79 upon animal life (*Proc. Nat. Hist. Soc., Glasgow,* 1879, p. 123 *et seq.*), *and* thereafter I published annual reports on Scottish Ornithology (*op. cit.*, 1880, pp. 291 *et seq.*, and 1881, pp. 41 *et seq.*) up to date of April 1881. After this date I found myself too busy with other matters to continue these land reports, as the correspondence entailed was very heavy, and I reluctantly gave up what I felt I could not continue with justice to the subject.

In Germany similar reports have been conducted by Dr Blasius for several years, the title of the last report being "VII. Jahresbericht (1882) des Auschusses für Beobachtungsstationen der Vogel Deutschlands (Separatabdruck aus Cabanis Journ. fur Ornithologie. Januar—Heft 1884)."

I may also mention in this place that application has been made to the British Association Migration Committee for copies of their schedules and letters of instruction from China and Japan and from New Zealand, and that returns come to that committee also from Iceland, Faroe, Heligoland, and the Danish coast, as well as several from ocean-going steamers.

The Congress at Vienna will no doubt arrive at further conclusions, and ere long there will be a network of ornithological observatories all over Europe.

If so, the subject of uniformity of record must come to the front and be discussed also. I may say I have stated my views pretty fully to Herr Dr Gustav von Hayek, Secretary to the International Ornithological Congress at Vienna, on these points, both as regards uniformity of method in working out distribution of species and for the purposes of recording migrational phenomena, and I will not trouble you with all the details here. But regarding records of rare occurrences I would like to say just a few words, and to suggest that some such form as I give an outline of here should be adopted by this Society, as well as all others, to insure greater uniformity of record. I have elsewhere spoken more fully about the working out of this method [*v.* "Zoologist," Feb. 1884, p. 60, March, p.

109 (J. E. Palmer), and April 1884, in which last I show how little form-books for register could be used with counterfoils, one-half of the sheet to be sent to the printer, and the other, in duplicate, retained by the recorder—the latter forming, when finished, a useful and permanent record of all rare occurrences in any given district, and always available to workers of the future].

The following form may be modified or amplified, but we believe, from the experience gained in five years' work on the Migration Committee, that the items here given would be sufficient for useful purposes:—

PLAN OF FORM FOR RECORDING WITH GREATER UNIFORMITY THE OCCURRENCES OF RARE BIRDS OR OTHER MIGRATIONAL PHENOMENA.

Date.	Locality and District.	SPECIES.	Age—Ad. or Juv.	Sex—♂ or ♀.	Alone or in Company	With its own Species.	Or others.	If the latter, name the No. and Species.	Flying in which Direction when shot or seen.	Direction of Wind and strength.	Prevailing Winds for—say the past week.	Weather.
1883. Nov. 1.	N. Uist, Hebrides.	*Larus minutus.*	Juv	?	Alone.		.		S.	Light, S.S.W	Light, S. & W.	Mist.

Destination Mus., Sir J. C. Orde.

REMARKS.

This specimen of the Little Gull was shot by Mr John Macdonald, factor for Sir John Campbell Orde, Bart., *in whose collection it now is.* It is a young bird of the year, and was the only one observed. It had come from the island of Bernera in the Sound of Harris, where it had been seen the day before. Wind southerly and westerly, and light for several days before and on day of capture. Weather misty. When it was obtained, it was found to have one foot awanting. Bernera is a sandy island, with a considerable shallow fresh-water loch, and a stretch of fine sand below high tide mark. It has a considerable population, and is grazed by a number of Highland cattle. The loch is full of eels.

In conclusion, form-books, with leaves for single records, would be useful for records of rarities, whilst larger record

books could be used for daily observations of flocks or the movements of birds and other phenomena, with certain modifications, and with the assistance of contractions and symbols, such as "f" for flock, "ff" for flocks, "lff" for large flocks, "sff" small flocks, etc., etc. Perhaps the best contractions and symbols in use for daily observations are those used for many years by Professor Newton of Cambridge, which are deserving of universal adoption, and are simple and easy to understand (see *Trans. of Noy. and Norw. Nat. Soc.*, vol. i., p. 32). For purposes of records of distribution, a progressive system of symbols has already been advocated by me (*Ann. and Mag. Nat. Hist.*, 1877, July, September, and December), which I still use, and find can be easily worked.

VIII. *On the Occurrence of the Black Redstart* (Ruticilla titys, *Scop.*) *at Pentland Skerries, Pentland Firth; along with a special plea in favour of Ornithological Education.* By John A. Harvie-Brown, Esq., F.R.S.E., F.Z.S., President.

(Read 23d April 1884.)

This specimen of *Ruticilla titys*, the fifth recorded occurrence of the species in Scotland as far as I am aware, is an adult male.[1] As already pointed out by me, on the occasion of my former record, it has occurred as far north as Faroe, and at its furthest north point on the Continent in the central districts of Sweden. The remarks made by me before regarding the extension of range northward in the breeding season, affecting the so-called *accidental* occurrences of the same species in autumn, apply still; and if we admit, which may be freely admitted, that birds return in great measure to their breeding haunts by the same routes that they leave them, then the more northerly occurrences in this country in perfectly normal weather indicates a more northerly extension abroad also. It may be argued that if this increase had been going on steadily, more marked differences would have

[1] For previous records, see the *Proceedings* of this Society, vol. iv., p. 142 (J. A. H.-B.); and Mr Gray's "Birds of the West of Scotland," p. 84.

been observed, and we would have more records year by year; but then it must be remembered that migration is in great part conducted at night, and it is often only the attraction by light in foggy weather, which by bringing the birds down within our reach of record, lets us know of their presence at all. Were our lighthouse-keepers all equally skilful in detecting the rarity of many of their annual visitors—and naming them—our work would be greatly simplified, and without doubt many records of rare birds would annually be added to our lists. We are glad to be able to say that the interest taken in the subject has not diminished amongst those who from the first have assisted the migration committee but has very greatly increased, whilst there have from time to time been appeals made by the men to have instructions in taxidermy, and books to assist them in the identification of rarities or of birds new to them. I mention this here because it may at a future time be in the power of some of our number to give a lesson, or leave some book or taxidermist's manual at a lighthouse. I have supplied books to a few of the important stations, but books are not to be obtained for nothing, and there are sixty-five stations in Scotland alone. The best results have followed at the stations which are provided with books. At Isle of May, Mr Agnew and his sons, as well as the underkeepers, can in a great many cases identify the rarer stragglers. It is my opinion that in this advanced age of education, what has been hitherto left to private enterprise to accomplish ought to be undertaken in a more liberal spirit, and that every lighthouse and lightship on our coasts should be supplied with a work on British birds, with sufficiently accurate portraits of every bird given. I sent "Mudie's British Birds" (Bohn's edition) to Mr Agnew, but it is not a very satisfactory production. All other works we have are either so expensive, or, where cheap, so imperfect, either as regards the plates or the text or both, that it is quite beyond the reach of any ordinary private income to distribute these with any satisfaction or hope of after results. If the Trinity House, and the Commissioners of Northern and of Irish Lights, would undertake the distribution of a good reference

work to all the stations, they would confer a boon upon the men themselves, and lighten many a tedious hour. When it is mentioned that on the island of Heligoland, Herr Gaetke has, during his thirty years' residence there, educated almost every man, woman, and child on the island to a pitch of field ornithological knowledge which is on a level with that of many amongst professed naturalists, it is only to instance what might be done in this country by the judicious expenditure of a little money and the addition of a few more volumes to the lighthouse libraries.

RECORD FORM.

Date.	Locality.	SPECIES.	Age—Adult or Young.	Sex.	Alone, or	with others,	of its own,	or other Species[1]	Direction of Wind,	and Strength.	Prevailing Wind for past Few Days.	Weather.
1884. Mar. 31.	Pentland Skerries.	*Ruticilla titys* (Scop.).	Ad.	♂	...	×	...	×	S.E.	Strong.	S. & S.E.	Clear on 28th. Fog on 31st.

REMARKS.

[1] **If with other species, name them here:** 1 Robin, Sandpipers, 1 Yellow Bunting, 1 Chaffinch, "Stonechats" (*i.e.*, Wheatears), 1 G. C. Wren, 1 Common Thrush.

IX. *List of Shells and Zoophytes from the Firth of Forth not hitherto recorded in the Society's* Proceedings. By JOHN R. HENDERSON, Esq.

(Read 23d April 1884.)

1. *Lima loscombii* (G. B. Sowerby).
2. *Tellina crassa* (Gmelin) var. *albida.*
3. *Scalaria trevelyana* (Leach).
4. *Trichotropis borealis* (Broderip and Sowerby).
   One specimen approaching Jeffreys' var. *acuminata.*
5. *Trophon barvicensis* (Johnst.).
6. *Philine scabra* (Müller).

With the exception of the white variety of *Tellina crassa*, dredged to the south-west of Inchkeith, in five fathoms water, all the above were brought in on the lines of the Newhaven fishermen, probably from the mouth of the Firth, and were collected by myself in 1883-84.

Jeffreys mentions that *Scalaria trevelyana* was found by Gerard in the Firth of Forth.

We are probably indebted to Captain Laskey for the discovery of *Trichotropis borealis.* About the beginning of this century he found at Dunbar a minute shell, which he figured in the *Memoirs of the Wernerian Society*, vol. i., as the young of Pennant's *Murex carinatus.* In 1841 Professor M'Gillivray found the same shell at Aberdeen, and named it *Fusus Laskeyi*, but he afterwards identified it as the young of *Trichotropis.*

Mollusca previously recorded, but rare in the Firth:

1. *Nucula tenuis* (Mont.).
   Newhaven.
2. *Arca tetragona* (Poli).
   Newhaven. Found by Mr J. Robertson.
3. *Cyprina islandica* (Linn.).
   A curious distortion. Portseaton beach.
4. *Venus casina* (Linn.).
   A distorted valve. Newhaven.
5. *Thracia convexa* (W. Wood).
   A large perfect specimen. Newhaven.

Zoophytes not previously recorded from the Firth of Forth:

HYDROIDA—

Sertularia fusca (Johnst.).
Newhaven. From deep water. November 1883.

POLYZOA—

Bugula flabellata (J. V. Thompson).
Newhaven. November 1883.

Cellepora dichotoma (Hincks).
Newhaven. Not rare on zoophytes from deep water, especially *Hydrallmania falcata* and *Antennularia ramosa.* It has perhaps been previously confounded with *Cellepora ramulosa.*

X. *On Scottish Fossil Cycadaceous Leaves contained in the Hugh Miller Collection.* By J. THEODORE RICHARDS, Esq., B.Sc., Falconer Memorial Fellow of the University of Edinburgh. (Communicated by Dr TRAQUAIR, F.R.S.)

(Read 23d April 1884.)

In a lecture "On the less known Fossil Floras of Scotland," published in "The Testimony of the Rocks" (Edinb., 1857), Hugh Miller has given a brief description, with accompanying figures, of several varieties of plant-remains occurring in the Jurassic strata of the north of Scotland. Among them are included specimens of the foliage of Cycadaceæ, comparable with those which constitute so great a part and so characteristic a feature of Jurassic floras elsewhere. Stems belonging to this order, derived from the Scottish Oolite, have had their characters described in detail by Dr Carruthers in his monograph "On Fossil Cycadean Stems from the Secondary Rocks of Britain" (*Trans. Linn. Soc.*, vol. xxvi.); but the leaves designated "Zamia" in the work above-named, and now preserved in the Hugh Miller Collection in the Edinburgh Museum of Science and Art, have not yet received detailed description or names. The following notice forms part of a general report on the systematic arrangement of British fossil Cycadaceous leaves, which has just been presented to the University of Edinburgh, and I am indebted to Dr Traquair for the opportunity of communicating to this Society the result of my examination of Scottish specimens. For three out of the five in question, which I have been unable to identify with any species described elsewhere, specific names and diagnoses are proposed. Two of them belong to the genus *Podozamites* (Fr. Braun), and the other to *Zamites* (Brong.), as these genera have been constituted in Schimper's classification, and are now commonly adopted. In the absence of any English work upon the subject, it may be stated that in *Zamites* are included leaves, of which the well-known *Zamia gigas* (L. and H.) is a typical example, whose segments, alternately arranged on either side of a strong rachis, are of oblong or lanceolate form, inserted towards the

front of the rachis by a slightly contracted callous base, and ending usually in an acute apex, with veins which, while they have a general parallel direction, diverge in passing outwards, so as to be cut off successively along the upper and lower margins of the leaflet. In *Podozamites*, which finds its type in *Zamia lanceolata* (L. and H.), another well-known Scarborough fossil, the segments, mostly slender and elongated, are characterised by a more marked narrowing at the base, forming often a kind of pedicel by which the leaflet is inserted, while the veins usually converge towards both extremities instead of terminating along the margins. (Heer, who has made known many new species and varieties of the latter genus, suspects that ultimately both genera may be reunited to the living *Zamia*.) Another of the Scottish leaves seems to be identical with *Ctenis falcata* (L. and H.), an abundant fossil in the lower Oolites of the Yorkshire coast. The remaining one is not a Zamioid leaf, the drawing of it having been associated with the others in Hugh Miller's book by an accidental error. The details which follow respecting each will be readily understood with the aid of his figures. It is only necessary further to mention that the strata of Eathie, near Cromarty, and of Helmsdale in Sutherlandshire, which yielded these remains, and are spoken of as Lias and inferior Oolite respectively, have since been assigned by Mr Judd (*Quart. Jour. Geol. Soc.*, vol. xxix., p. 181) to the upper division of the Jurassic system. The relation of the specimens here described to plants of the same system elsewhere is discussed in each case below.

GENUS ZAMITES—*Brong. emend.*

Zamites Eathiensis, sp. nov.

"Zamia," Hugh Miller, Test. of the Rocks, p. 476, fig. 133.

Foliis magnis, decim. 3 et ultra longis, pinnis subremotis, rachi crassæ perpendicularibus, pro more suboppositis, millim. 10-13 latis, basi apud marginem inferiorem leniter constricta oblique insertis, persistentibus, nervis leniter divergentibus.

This, the most conspicuous example of Scottish Zamioid foliage, derived from Eathie, in the neighbourhood of Cromarty,

is among the larger leaves of fossil Cycadaceæ, which are diminutive in comparison with their modern representatives. Its length, of which more than a foot is visible—its "strong, woody midrib,"one-third of an inch in thickness, perfectly preserved in cylindrical form—its leaflets, half an inch in breadth, all indicate a plant with dimensions approaching those of *Zamites gigas.* That it, too, was a *Zamites,* is without doubt. The exact outline of the leaf cannot be determined, since the rachis throughout its length gives rise to leaflets of which only the proximal parts remain, without any indication of the apices, and these portions are of nearly the same size and form in all parts of the specimen. The length of the leaflets, therefore, and their mode of termination are uncertain; but as the present state gives a width of 4 inches, perhaps 6 inches or more may have been the original width of the leaf; which is seen in back view. The segments at the upper part, equally with those below, are at right angles to the rachis, and all are separated by well-marked intervals from one another. Hugh Miller states erroneously that they "were rectilinear, retaining their full breadth until they united to the stem at right angles" (*loc. cit.*, p. 477). The upper margin does indeed pass to the insertion without deflection, but the pinnæ are distinctly constricted at the under margin of the base. All remain attached to the rachis, the mode of insertion evidently rendering the attachment persistent. The union takes place in an oblique direction, so that the leaflets occupy oblique planes, as in *Z. gigas.* They are, as shown in the drawing, nearly opposite to one another on the two sides, excepting in one place, where two on one side are opposite to three on the other. The veins are strongly marked, diverging slightly from their wide origin at the base, so as to terminate along the upper and lower margins.

With the characters now described, resembling *Z. gigas* chiefly in size, the Eathie leaf will be found most closely related to *Z. Feneonis* (Brong.), which is a species of the middle Oolites of France. The older figure of this, by Ettingshausen (*Lias. u. Oolith. Flora*, Abhandl. der Geol. Reichsanstalt, Wien, i., 1852, p. 9, t. iii.), which happens to be copied at p. 39 of Hugh Miller's work, would lead us, I

think, to identify the two, if no other information were available. The complete descriptions, however, and numerous drawings by Saporta of the French plant (*Pal. Française, Végétaux Jurassiques*, vol. ii., *Cycadées*, p. 99 and plates) have prevented me from doing so. From these it appears that *Z. Feneonis* never attains the dimensions of the Scottish specimen, while it is usually much smaller, and often quite small. The imperfection of the example makes it uncertain whether the breadth of the leaf was as great in proportion to its length as is the case in *Z. Feneonis*, nor can it be determined whether the leaflets were of the same acuminate form. These, as already stated, do not at any part of the specimen, throughout the 12 inches seen, depart from the strictly horizontal direction, nor are they ever contiguous to one another. In *Z. Feneonis*, on the other hand, the leaflets are usually contiguous, or much more close together, and at the apex of the leaf they are suberect and narrow. Their width, in the largest examples figured, does not exceed one-third of an inch, whereas in all parts of the Eathie fossil they have a breadth of half an inch; so that while the foreign species, alike in the older and more recent figures, has at least eleven to thirteen leaflets on each side in the space of 4 inches, we have only seven in the same space. The insertion of the pinnæ and the stout rachis of *Z. Feneonis* (not the var. *articulatus*, Sap.), as represented in both places, seem to be almost identical with the condition in the leaf before us, but that the lower margin is in both oftener shown to be straight, while in this it is the upper. Lastly, there is scarcely indicated in *Z. Feneonis* any departure from a strictly alternate arrangement. The only other form of considerable size with which the specimen could be compared is *Z. Moreaui* (Brong.), which differs in some of the same, and in other respects. There seems, therefore, good reason for the description of the Scottish fossil as a new species of *Zamites*. A remark of Saporta on the comparison of different species, some of them new, which he describes, may here be quoted: "Il ressort du reste de cette étude comparative la conviction que les *Zamites* constituaient dans la flore jurassique une groupe très-compacte de formes revêtues d'une physionomie commune, sensible-

ment la même pour toutes, et chez lesquelles de faibles différences suffisaient pour motiver des distinctions spécifiques" (*loc. cit.*, p. 96). The close resemblance of the plant to the Corallian species of France will be noticed in connection with the position assigned to the Eathie rocks in the memoir already cited.

GENUS PODOZAMITES—*Fr. Braun emend.*

Podozamites Milleri, sp. nov.

"Zamia," Hugh Miller, Test. of the Rocks, p. 479, fig. 137.

Foliis rachi validiuscula, pinnis approximatis, regularibus, erecto-patentibus, centim. 7-8 longis, millim. 7-9 supra basin latis, lineari-lanceolatis, acuminatis, basi subito fere margine superiore deflexo in pedicellum brevem angustatis.

The specimen now to be described is from the Oolite of Helmsdale. It is stated by the author very closely to resemble Lindley and Hutton's *Zamia lanceolata* (*P. lanceolatus* var. *genuinus*), but that the leaflets "contract much more suddenly from their greatest breadth than those of *lanceolata* into a pseudo-footstalk; and the contraction takes place, not almost equally on both sides, as in that species, but almost exclusively on the upper side." To this must be added the greater uniformity in size, shape, and arrangement of the leaflets, which, as will be seen from the figure, pass obliquely outwards in a very regular manner. Their size and outline, excepting so far as the base is different, are very much those of the typical (English) form of *P. lanceolatus*, but the loose and irregular appearance of the latter, with its slender rachis, gives it a distinct character, which belongs also more or less to all the varieties of the species. The Helmsdale leaf seems to be one of more rigid habit. The length of the portion seen is 8 inches; its rachis is comparatively strong; and the leaflets, 3 inches in length and oblique in direction, are nearly straight, and almost contiguous to one another. The pedicels also are strong, and probably somewhat decurrent on the rachis. The manner in which they are formed, as shown in the drawing and described above, is seen in so many places that the appearance can hardly be accidental. The greatest width of the leaflet is at half an inch or less

above the insertion, beyond which it gradually narrows to the apex. Below this point, the lower margin turns up slightly to the pedicel with great uniformity in each segment, while the upper margin, with equal constancy, descends in a nearly vertical direction for some distance, until it joins the pedicel and becomes its upper border. *P. lanceolatus* itself varies in the mode of formation of the pedicel; thus, in the type *genuinus* either margin may turn in more at the base than the other, while in the var. *Eichwaldi* the leaflets appear to be usually symmetrical at the base, but the regularity which characterises the Scottish specimen in this and every respect is against regarding it as another variety of the same. In the direction and arrangement of its leaflets, and to some extent also in their form and insertion, it has more analogy to *P. angustifolius* (Eichw.), but in this the lower margin is the one which is uniformly most curved to meet the decurrent pedicel, and the leaflets are much more slender. The forms with which comparison is thus suggested belong to the lower and middle Oolites of various countries.

Podozamites Heerianus, sp. nov.

"Zamia," Hugh Miller, Test. of the Rocks, p. 478, fig. 136.

Foliis majusculis, pinnis æqualiter distantibus, erecto-patentibus, linearibus, centim. 12 *circa longis, millim.* 9-10 *latis, basin versus longe et sensim angustatis, apice acutis vel subacutis.*

The third specimen belongs also to the genus *Podozamites*, which has been so much extended by recent research in all parts of the world. This consists of a portion of a frond, with long and narrow leaflets in relation to a rachis, from which, however, most of them are detached, although still retaining their order. Only one, which lies separate from the rest, is nearly perfect; the termination of the others is not seen. They were not less than 4¼ inches long, and at their widest part only ⅜ inch broad. This is reached nearly 3 inches from the base, and throughout this distance they slowly narrow to their insertion, contracting also in the opposite direction to probably an acute or subacute apex. They are arranged with considerable regularity at a slight distance from one another, forming acute angles with the

rachis. The veins are sufficiently distinct, as shown in the drawing. No species previously described seems to possess characters corresponding with the above. *P. angustifolius* (Eichw.) is perhaps the nearest, but it is much smaller, the leaflets in Eichwald's figure (*Leth. Rossica*, vol. ii., tab. ii., fig. 7), which is of natural size, having but half the length and width of these; their greatest width occurs near the base, where they are therefore most approximated, and from which they gradually narrow outwards. The fragmentary specimens figured by Heer (*Beitr. zur Foss. Flora Spitzbergens*, tab. vii., f. 8-11, viii., 2e, 5; *Beitr. z. Jura. Fl. Ost. Sibir. u. d. Amurlandes*, tab. xxvi., f. 11; *Beitr. z. foss. Fl. Sib. u. d. Amurl.*, tab. v., f. 11b.) with this name are somewhat difficult of determination. There can therefore be little hesitation in assigning to the leaf, derived from the same locality as the last, the position of a new species, which I have dedicated to the memory of Dr Heer.

? CTENIS FALCATA—*L. and H.*

"Zamia," Hugh Miller, Test. of the Rocks, p. 478, fig. 135.

I am unable to separate from this well-known Scarborough species the leaf here figured from the Oolite of Helmsdale. The specimen is of the same size as the Yorkshire plant; its leaflets have the same form and arrangement, the same mode of insertion, and apparently the same venation. Division and anastomosis of veins are not indeed to be detected, but similar divergence at the base is seen, and the veins are as large and conspicuous as they usually are in English specimens, and of corresponding number. The decurrence of the leaflets behind one another at the base, and a slight narrowing sometimes beyond the insertion, are equally characteristic. The leaflets, perhaps, are closer together, and may be a little more oblique than they are, as a rule, in the Yorkshire specimens, which, however, vary in these respects. As usual in the latter, their apices are not seen. The upper part of the specimen will be observed closely to correspond with Lindley and Hutton's figure ("Fossil Flora," vol. ii., tab. 103). In the meantime, therefore, it may be regarded as continuing *Ctenis falcata* to a higher level in the Jurassic system.

Hugh Miller has himself suggested the identity on a label affixed to the specimen, although it is not so spoken of in the work where it is figured. It may be remarked that the figure shows a singular resemblance to that by Tate of the smaller leaf *Palæozamia Rubidgei* (*Dioonites Rubidgei,* Sch.) from South Africa (*Quart. Jour. Geol. Soc.*, vol. xxiii., p. 145, pl. v., fig. 3). The likeness, however, disappears in the enlarged drawing of a single leaflet of the latter. Palæontologists are not agreed whether *Ctenis* is a cycad or a fern.

With reference to the remaining figure in the "Testimony of the Rocks" which bears the name of "Zamia" (p. 477, fig. 134), it has to be remarked that, after describing the Zamioid foliage, the author goes on to refer in some detail to the group of simple-leaved ferns, including *Tæniopteris,* and indicates his own belief that certain large Scottish specimens which would usually bear this name may be truly Zamioid. It is one of these, doubtless, which is figured, with the name of "Zamia" attached, in this place, where it has apparently been inserted in error by those who assigned to some of the drawings their position and name after the author's death. (See note prefixed to the work.) Its interpolation here among the other four figures we have quoted (figs. 133, 135, 136, 137), representing plants mentioned in corresponding order in the text, has confused the references to these; and we find further on (p. 484) that it is required to complete the illustration of Tæniopteroid plants as there described. Leaves of this kind are still included among ferns, especially several of great size in the genus *Macrotæniopteris* (Sch.).

XI. *On a Specimen of* Pecopteris (? polymorpha, *Brongn.*) *in Circinate Vernation, with Remarks on the Genera* Spiropteris *and* Rhizomopteris *of Schimper.* By Robert Kidston, Esq., F.G.S. [Plate V., Fig. 1.]

(Read 19th December 1883.)

Although the beautiful specimen which forms the subject of this communication does not throw any additional light on

the growth of fossil ferns, yet as none of the figures of circinate vernation with which I am acquainted surpass this example, I have ventured to give a short description and a figure of it.

The fossil is about 3 inches long; but if we measure the full length of the circinately rolled-up portion as if it were straightened out, it is fully 6 inches in length. The specimen is, however, incomplete at its lower extremity; so its original size cannot now be ascertained.

The rachis is thick, and still shows slight traces of the little scales with which its surface was once covered. The inner side of the rachis bears about thirty-three circinately rolled-up pinnæ. These show nothing further than the midribs of the pinnules which appear as strongly-defined ridges. There is no evidence in the specimen itself to indicate the species to which it belongs; but from the occurrence of fragments of *Pecopteris polymorpha* (Brongn.) on the same slab,[1] it probably belongs to that fern.

The specimen is in the collection of the Geological Survey of Great Britain, to whom it was presented by Mrs Stockhouse Acton.

My thanks are due to Dr A. Geikie, F.R.S., Director-General of the Geological Survey of Great Britain, for permission to describe this interesting fossil.

Position and Locality.—From the Coal-measures, Leebotwood, about nine miles from Shrewsbury.

As a means of giving a definite place in the classification of fossil plants to such fossils as that just described, Schimper has proposed the genus *Spiropteris*,[2] in which he places those specimens of ferns that do not afford sufficient characters for the determination of the species to which they belong. For fossils of this nature the genus is very useful, as it gives a fixed, though provisional, position to many interesting specimens which cannot be specifically associated with the fully-developed frond.

[1] Not shown in the figure.

[2] Traité d. Paléont. Végét., vol. i.. p. 688, pl. xlix. (1869).

Several very interesting examples of *Spiropteris* have been already described.

In 1828 Brongniart[1] figured a *Spiropteris*-condition of *Pec. Miltoni* (Artis), which shows a few of the pinnæ spirally coiled.

Göppert gives a figure of circinate vernation of *Pec. Jägeri.*[2] It exhibits a very young condition of probably a whole frond. He also gives another specimen of *Spiropteris* on his Pl. xxxvi., Fig. 8.

Probably the most interesting figures of *Spiropteris* are those given by Germar,[3] which he named *Selaginites Erdmanni.* These, as Schimper has pointed out, are not Lycopods, but young ferns,[4] and referable to *Spiropteris.* Though the specimens are of considerable size, they show merely the early condition of a large frond. The dense covering of scales with which they are bedecked, gave rise to the mistaken opinion that the fossils were Lycopods and the scales their leaves.

A small specimen of *Pec. arborescens* (Schl. sp.) in circinate vernation has been figured by Geinitz in his "Verst. d. Steinkohlenform. in Sachen."[5]

Sir C. J. F. Bunbury described a very curious fossil fern from the Sydney Coal-field, Cape Breton,[6] which showed portions of a frond in circination.

This specimen beautifully exhibits numerous long scales on the rachis. Some of the lateral pinnæ are fully expanded; but these, unfortunately, are not sufficiently well preserved to enable one to determine the species to which the fern belongs. Bunbury regarded it as a *Pecopteris* standing in the neighbourhood of *P. plumosa* (Brongn.).

From the scales on the rachis Mr R. Brown, who found the specimen, "supposed it to belong to a peculiar species

[1] Hist. d. Végét. Foss., p. 334, pl. cxiv., fig. 1.

[2] Die fossilen Farrnkräuter, p. 368, pl. xxii., fig. 6*a* (1836).

[3] Die Verst. d. Steinkohlengebirges v. Wettin u. Löbejün, p. 61, pl. xxvi. (1844).

[4] Schimper, Traité d. Pal. Vég., vol. i., p. 689.

[5] P. 24, pl. xxviii., fig. 10 (1855).

[6] Quart. Journ. Geol. Soc., vol. viii., p. 31, pl. i. (1852).

of *Lepidodendron;*"[1] but there can remain no doubt as to the fossil being a fern referable to *Spiropteris*.

The same writer in 1857[2] figured and described a specimen of *Neuropteris* (probably, as suspected by the author, *Neur. gigantea*, Sternb.) circinately coiled, from Glodwick Colliery, near Oldham, Lancashire.

Examples of *Neuropteris* in this condition are even more rare than those of *Pecopteris*.

The figure which accompanies his paper shows a very perfect example with the usual accompanying scales on the rachis.

Mr T. Stock has shown me a small circinate specimen of *Neuropteris* from the Coal-measures near Dysart, Fife; but this one probably belongs to *N. Loshii* (Brongn.), as it was associated with that fern.

In the "Illustrations of Fossil Plants," which consists of a reproduction of a number of unissued plates prepared by Lindley and Hutton for their "Fossil Flora," three good figures of *Spiropteris* are given.[3]

Plates xlv. and xlvii. are referable to *Neuropteris*, but of that on Pl. xlvi. the genus is uncertain.[4]

In a paper on *Sphenopteris affinis* (L. & H.),[5] Mr C. W. Peach gives some good figures of the young state of this fern. His figures 6 and 7 show very clearly the characteristic dichotomy of the rachis of this species.

The above is a list of the chief Palæozoic examples of *Spiropteris* which have been figured and described; and it is remarkable, that though ferns are our most common class of fossil plants in the Carboniferous formation, specimens showing their early stages of development are so seldom met with.

There is another group of fossils which, though very similar

[1] Quart. Journ. Geol. Soc., vol. viii., p. 32.

[2] Bunbury, "On a remarkable Specimen of *Neuropteris*, with Remarks on the Genus" (Quart. Journ. Geol. Soc., vol. xiv., p. 243).

[3] Edited by G. A. Lebour, Newcastle-on-Tyne, 1877.

[4] See Crépin, Révision de quelques espèces figurées dans l'ouvrage intitulé "Illustrations of Fossil Plants" (Soc. Roy. de botanique de Belgique, vol. xx., part ii., p. 25, 1881).

[5] Quart. Journ. Geol. Soc., vol. xxxiv., p. 131, pl. viii., figs. 5-7.

in general appearance to *Spiropteris*, are most probably quite different in nature. For these Schimper has proposed the name *Rhizomopteris*.[1]

In this genus Schimper places the specimens which Geinitz has figured[2] as *Selaginites Erdmanni*, believing them to be fern-rhizomes; and certainly the fossils in question have a great resemblance to such structures.

There can be no doubt as to Geinitz's plants being quite distinct from those originally described under the same name by Germar.[3]

Schimper also places in his *Rhizomopteris* the *Selagonites uncinnatus* (Lesqx.).[4]

Lesquereux, though he says the specimen cannot positively be referred to the Lycopodiaceæ, still keeps it separate from *Rhizomopteris*, and includes it in *Lycopodites* (*L. uncinnatus*).[5]

I am inclined to regard this fossil as the rhizome of a fern; and the spiral terminations of several of the branches, which appear to be the chief character that prevents Lesquereux from regarding his plant as a rhizome, are most probably spirally-coiled young fronds springing from the points of the branchlets of the rhizome.

From the nature of the fossil and the state of its preservation, there is, however, room for difference of opinion as to its true nature.

XII. *On a New Species of* Schutzia *from the Calciferous Sandstones of Scotland.* By ROBERT KIDSTON, Esq., F.G.S. [Plate V., Fig. 2.]

(Read 19th December 1883.)

Schutzia Bennieana, n. s., Kidst.

Specific character.—Fruit campanulate, composed of linear lanceolate bracts; pedicels of fruits short and placed spirally on the axis.

[1] Schimper, *l. c.*, vol. i., p. 699 (1869).

[2] Geinitz, *l. c.*, pl. i., figs. 5 and 6.

[3] Geinitz figures in his "Flora der Kohlenform. v. Hainichen-Ebersdorf u. Flöher-Guckelsberg," p. 56, pl. xiv., fig. 20, a plant which he also names *S. Erdmanni.* This appears to be only a badly-preserved *Lepidodendron.*

[4] Geol. Survey of Illin., vol. ii., p. 446, pl. xli., fig. 3 (1866).

[5] Coal-Flora of Pennsylvania, p. 359 (1880).

Remarks.—The specimen on which the above description is based, shows the upper portion of a fructification, but its lower part is broken over, so that its original length cannot now be determined. The part which has been preserved is $3\frac{5}{16}$ inches long.

Only three fruits are attached to the stem, the terminal one and two immediately beneath it.

Below these are seen the scars from which four others have fallen. The spiral arrangement of the fruits is clearly shown by the position of those which still remain, that on the right being placed at about a third of the circumference of the stem distant from the one to the left hand.

The bracts of the little cones are about half an inch long, narrow, and terminating in a sharp point, and they appear to have had a central keel. From the compressed state of the fossil it is impossible to make out their arrangement clearly, but they were probably placed in a few spirals.

The stalks to which they are attached are short, being barely, in the longest and lowest example, the fifth of an inch long. The main axis is irregularly striated longitudinally.

Affinities.—This plant is closely related to *Schutzia anomala* (Geinitz),[1] from the Rothliegenden of Ottendorf, near Braunau, Bohemia;[2] but the differences between the Permian and the Scotch plant are such as to necessitate a specific designation.

They agree in the spiral arrangement of the little cones, in their being short-stalked, and in the furrowed stem, as also in the angle made by the pedicels and the stem.

The form of the fruit is, however, essentially distinct.

In *Schutzia anomala* they are globular, and consist of numerous and much shorter keeled scales, which are similarly

[1] Geinitz, Neues Jahrbuch, 1863, "Ueber zwei neue dyadische Pflanzen," p. 525, pl. vi., figs. 1, 2, 3.

[2] Göppert also notes the occurrence of this plant at Neurode, Silesia (see Die foss. Flora der permischen Formation, pl. xxiii., figs. 1-6, pl. xxiv., figs. 1, 2, 3, 5, 1864-65). The plates for this work were prepared before the publication of the paper by Geinitz, though not issued till after; hence the name which Göppert had proposed for this plant (*Anthodiopsis Beinertina*) appears on his plates; *Schutzia anomala* (Gein.) is used in his text. See also Göppert, Foss. Flora d. Uebergangsgebirges, p. 214 (1852).

arranged in a few short rows. These often appear blunt, but Geinitz thinks this bluntness may arise through a bending of their apices.

Schutzia Bennieana teaches nothing as regards internal structure; but in *S. anomala,* Geinitz thought he could discover, "at the base of the inner side of the fruit-scales, the appearance on each side of a longitudinal depression, which corresponded to the two seeds in the fruit-scales of Coniferæ."

In addition to the plates of *Schutzia* given by Göppert, he also figured another fossil, which he named *Dictyothalamus Schrollianus.*[1]

This he thought might belong to *Schutzia anomala,* the latter being the female, the former the male plant. These occurred together and often on the same slab.

The central part of *Dictyothalamus* is composed of small elongated roundish bodies, which Göppert thought were the seeds.

He believed these fossils might belong to the *Nœggerathiæ,* but Geinitz regarded them as coniferous.

As there occurred with the specimens *Nœggerathia* (*Cordaites*) and Coniferæ of different genera, as *Walchia piniformis* (Schl., sp.), and *Ullmannia,* no light is thrown on the affinities of *Schutzia* by the vegetable remains with which it was associated.

But that it does not belong to *Walchia* or *Ullmannia* is pretty certain, as the fruits of both these plants are now well known.[2]

Schimper unites *Dictyothalamus Schrollianus* (Göpp.) with

[1] Göppert, Die fos. Flora d. perm. Formation, p. 164, pl. xxiv., figs. 4 and 6, pl. xxv., figs. 1-4.

[2] Göppert figures and describes what he believes to be the fruit and the male flowers of *Walchia piniformis,* in "Die fos. Flora d. perm. Form.," p. 239, pl. xlix.,—the cones, figs. 1-10; the male flowers, figs. 11-14. See also Weiss, Flora d. jüng. Stk. u. d. Rothl., p. 179, pl. xvii., fig. 1. The fruit of *Ullmannia* was described as far back as 1828 by H. Bronn, in Leonhard's "Zeitchrift für Mineral.," Band ii., p. 509, pl. iv., under the name of *Cupressus Ullmanni.* Göppert also figures, in his "Permian Flora," similar cone-like fruits (pl. xlv., figs. 24, 25).

Schutzia anomala (Geinitz),[1] and regards the *Schutzia* as the female, and the *Dictyothalamus* as the male plant. The structure in the latter which Göppert believed to be seeds, Schimper thinks are stamens, and this view I am inclined to adopt. These remarks show that the real affinities of *Schutzia* are very obscure.

Schimper regarded these fossils as belonging to a "coniferous plant, which was altogether paradoxical and without any analogy, either fossil or recent."[2]

Although this is not a very satisfactory manner of disposing of *Schutzia*, the conclusions arrived at by Schimper may possibly be correct, though we have little positive evidence to support this opinion.

Large coniferous stems, with their internal structure beautifully preserved, are of frequent occurrence in various parts of the Calciferous Sandstones of Scotland. The remains of coniferous trees also occur in rocks of similar age in different parts of the globe; but notwithstanding their wide geographical distribution and frequency of occurrence, there is nothing definitely known regarding their fruit or foliage.

Prof. Dawson has described and figured a small coniferous-like branch from Tatamagouche (Carboniferous formation), which he has named *Araucarites gracilis*.[3] This, he thinks, may possibly belong to his *Dadoxylon materiarum*.[4]

Some botanists regard the Trigonocarpons as the fruit of Conifers, but this opinion is not universally accepted.[5]

The absence, however, of conclusive evidence as to the fruit and foliage of Palæozoic Coniferæ is not so surprising when we consider that the ancient pines most probably occupied the uplands of the then existing continents, and only the stems and larger branches would be able to resist

[1] Schimper, Traité d. Paléont. Végét., vol. ii., p. 358.

[2] *Loc. cit.*, p. 358.

[3] Dawson, Arcadian Geology, 2d edit., p. 474, fig. 159A (1868).

[4] Dawson, *l. c.*, p. 424. Stur also gives, in his "Culm Flora" (p. 81, pl. xiv., fig. 4), a small figure and description of a fossil he has named *Pinites antecedens.* The specimen is small, and its union with the Coniferæ appears a little uncertain.

[5] Since writing the above, Prof. Williamson, in his Address at the British Association, has given a *résumé* of this subject (Nature, Sept. 20, 1883).

the abrasion and decay of their long journey from the uplands to the flats, where mud or sand was being deposited; and as proof of this, many of the stems of these trees are found imbedded in sandstone quarries, where they have been drifted.

The undoubted occurrence of the genus *Schutzia*, so low down in the geological scale, is of considerable importance; the discovery in the Calciferous Sandstones of a plant so closely related to a Permian species, is almost without parallel.

The small fossils which I previously described and placed in the genus *Schutzia* are different from the present example, and their real claim to this genus may perhaps be open to question.[1]

Schutzia Bennieana comes so near the Permian species, that it is only after very careful consideration I have given it a specific designation.[2]

It gives me pleasure to name this plant after Mr J. Bennie, to whom I owe so much for kind assistance in many points connected with my study of fossil botany.

Position and Locality.—In bituminous shale, Water of Leith, opposite Kate's Mill, Midlothian; Calciferous Sandstone series. Collected by Mr James Bennie.

XIII. *On the Occurrence of Sabine's Gull* (Xema Sabinii, *Sabine*) *in Adult Plumage in the Isle of Mull.* By EDWARD BIDWELL, Esq., M.B.O.U.

(Read 20th February 1884.)

Although both the late Dr Saxby and Mr Thomas Edwards, of Banff, write of having seen Sabine's Gull, there are only two instances that I can trace of the bird having ever been obtained in Scotland. The first, an immature female, shot on October 2, 1877, near the island of Craigleith, in the

[1] Trans. Roy. Soc., Edinb., vol. xxx., p. 545, pl. xxxi., figs. 10, 11, 12.

[2] Schimper thinks the (?) *Trigonocarpus Rœssleri*, Gein. (Neues Jahrb, 1867, p. 288, pl. iii., fig. 4), is an analogous fruit, but specifically distinct (Traité d. Paléont. Végét., vol. ii., p. 358).

Forth, is now in the] of North Berwick. The late J a A xander Smith exhibited this bird at a meeting of your Society, and recorded it in the fourth volume of the *P ngs* (p. 207). The second is the bird which I am enabl to bring before your notice to-night, through the kindn of the Rev. F. Weldon Champneys, who writes me as foll ws:

"East Lodge, Frant,
"Tunbridge Wells, *January* 26, 1884.

"The Sabine's Gull, which I was fortunate enough to obtain last autumn, is a male. It was shot on Loch Spelve, Isle of Mull, September 7 or 8, 1883. There had been some very rough weather. I saw it swimming about on the loch, the weather and water being then quite calm. It allowed our boat to approach within 35 to 40 yards, when it slowly rose in flight. I shot at it with No. 3 shot, and though I had hit it hard, it flew about 150 yards and settled again, just as if not hurt. However, on rowing up to it, it allowed me to take it up in my hand. One shot seemed to have gone into its heart, but it was most tenacious of life, and took me some minutes to kill it, so as not to hurt its plumage.

"It struck me at the time, from its tameness, that it did not know much by experience of human nature."

The earliest known specimen of this species is one now in the Vienna Museum, which was received without any published name or description from the Ornithological Institute of that city, about 1806. Some twelve years later, the species was described in a paper read before the Linnean Society by the late Joseph Sabine, F.R.S., and in the 12th volume of the *Transactions* a plate was given of the bird, which was named after its discoverer, his brother, the late Sir Edward Sabine, who, when accompanying the expedition in search of the North-West Passage, obtained it in July 1818 on some small rocky islands off the west coast of Greenland.

The first British example of this bird of which we have

any authentic record was an immature specimen shot in Belfast Bay, September 18, 1822, and recorded by Thompson in the third volume of his "Natural History of Ireland" (p. 310). I have compiled a list of some nine other Irish and twenty-four English specimens obtained since that year. Of the ten Irish, eight were killed in September and one in October, no month being given for the remaining bird, autumn only being added for date. Six of these were taken in the neighbourhood of Dublin, three in Donegal, and one in County Down. It is certainly strange that, whilst nearly one-third of the recorded British specimens have been obtained in the west and north of Ireland, until last year it has never been met with on the west coast of Scotland. Of the twenty-four English specimens, all except one were met with in the months of September, October, and November. Ten of these were obtained on the west and south coasts, extending from the Bristol Channel to Eastbourne, and eleven of the remainder between Scarborough and the Thames; the Yorkshire coast being credited with eight, whilst it has been obtained in such inland counties as Cambridgeshire, Shropshire, and Warwickshire.

All the above were birds in the plumage of the first year, with the exception of one obtained in Bridlington Bay on August 10, 1872 (*cf. Zoologist,* 1872, p. 3316), which was in full summer plumage, and it is strange that one of the only five known instances in this state of plumage met with in Europe was a male obtained off the coast of Brittany on August 25, 1872, just fifteen days after.

You will see from this the peculiar interest attached to the bird now before you, it being only the second example obtained in Britain, as it is also only the fifth in Europe that has reached maturity.

With reference to the records of this bird in Europe, it is interesting to note that Müller obtained it at Thorshavn, Faröes, on January 26, 1856. It has not been found in Sweden, Norway, or Russia. It has been met with once in the island of Heligoland. Dr Altum records it twice in Münsterland. One, a male in full plumage, has no locality given. Holland, Holstein Hungary, Picardy, and Dunkirk,

are each credited with an example; and again, Degland mentions an adult shot at Rouen.

The true home of this bird is on the borders of the Arctic Circle; and, since its eggs were first taken by Sabine, on the west coast of Greenland, it has been found breeding on Melville Peninsular by Sir Edward Parry; on Cape Dalhousie by Sir John Richardson; on Prince Albert's Land (*cf.* Captain Feilden, *Zoologist*, 1879, p. 8) in Franklin Bay, and Alaska. Middendorf found it breeding on the tundras of the Taimyr; and the remains of an egg taken by him were exhibited by Professor Newton, at a meeting of the Zoological Society, on December 10, 1861.

The few eggs that are to be found in collections were procured by the Arctic Expedition sent out at the instance of the Government of the United States, and were taken by Mr R. Macfarlane in Franklin Bay in 1865. Your Museum of Science and Art is indebted to the Smithsonian Institute at Washington, for one of these oological treasures.

In early autumn these birds migrate southwards, especially following the coast lines of North America. It has occurred once on the Bermudas, and lately as far south as Peru, in 12° S. latitude.

Through the kindness of Mr Howard Saunders, I am enabled to place before you skins of Sabine's Gull in three stages of plumage. The first is a bird of the year, the same as the bird obtained on the Forth. It was killed on the Thames in 1862 (*cf.* Harting's "Birds of Middlesex," p. 251). The second in breeding plumage is like the Loch Spelve specimen. The third in winter dress, was killed in December at Callao. You will notice that it has lost its hood, the forehead especially being white, whilst the nape has assumed black feathers, where white in summer.

In this stage, until a very few years ago, the bird was unknown. It is even now excessively rare, Mr Howard Saunders possessing the only two specimens in Europe—this being one of them; a third being in America.

The genus *Xema*, which was founded by Leach, contains only one other species besides *X. Sabinii*, namely, the Fork-tailed Gull (*X. furcatum*, Neboux), a bird which, were it

not for the white feathers at the base of the upper mandible and the absence of the black collar, might be best described as "a gigantic Sabine's Gull." Of it three specimens only are known—one in Paris—the type; a second in the British Museum from the Galapagos; and a third from Peru is in the rich collection of Gulls belonging to Mr Howard Saunders. This, a bird of the year, is figured in the *Proceedings* of the Zoological Society for 1882, Plate xxxiv. Nothing is known of its breeding haunts.

In the list of occurrences of North American birds in Europe, so carefully compiled by Mr J. J. Dalgleish, mention is made of two species of North American Gulls as having been met with in Great Britain, and it was to one of these, Bonaparte's Gull (*Larus philadelphia,* Ord.), that Mr Champneys' bird was attributed, until I saw it at Mr M'Culloch's shop in Glasgow. As Bonaparte's Gull has most undoubtedly been met with in Scotland, and as it bears a resemblance in many ways to Sabine's Gull, I am not surprised at the mistake. I have brought skins of this species for comparison.

The other species is the Laughing Gull (*Larus atricilla,* Linn.). It has been included in the British list on the authority of Montagu, but recent writers are agreed that the record is erroneous.

The bird may always be known by its black primaries, the knowledge of which fact might possibly be the means of the bird being recognised, should it ever be killed on the British coast.

XIV. *A Revised List of British* OPHIUROIDEA. By W. E. HOYLE, Esq., M.A. (Oxon.), F.R.S.E., M.R.C.S., Naturalist to the "Challenger" Commission.

(Read 19th March 1884.)

No attempt appears to have been made to compile a complete list of the Ophiuroids which frequent our seas, since the Rev. A. M. Norman published one nearly twenty years ago;[1] and since I have recently had the opportunity of examining the collections made by H.M.S. "Porcupine" and

[1] Ann. and Mag. Nat. Hist., ser. 3, vol. xv., pp. 104-115, 1865.

"Triton," it occurred to me that a list with such additions as were made by these expeditions, or could be found in the recent literature of the subject, might not be without use to my fellow-workers in this field.

The meaning of the word "British" used in the title of this paper perhaps requires a little definition. Since the channel between Scotland and the Faröe Islands, besides lying within a short distance of our shores, has been mainly explored by British vessels, it has appeared desirable to include it. I have thought it well similarly to include forms from off the west coast of Ireland and Scotland down to the 500 fathom line, but only very few have come under my notice from that locality.

For remarks on the relations between the British Ophiuroidea and those of other seas, I may refer to the Report on the "Triton" Ophiuroidea.[1]

The authors to whom I have had occasion to refer will be found noted in the body of the paper, but I cannot here refrain from alluding to the great obligation under which all, who are interested in this group of animals, stand to Professor Theodore Lyman, for his Report upon the "Challenger" Ophiuroidea, which is indeed a complete monograph of the order. I have, with very few exceptions, adopted his nomenclature, and the number of times his name occurs in this paper will prove my indebtedness to his great work; in addition to which I must acknowledge his courtesy in answering certain questions which I put to him.

Professor Lyman has adopted the system often followed by American naturalists, but not generally adopted in this country, of quoting as the authority for each species the name of the observer by whom the combined name (generic and specific) was first used, often to the exclusion of the earliest describer of the species. This plan seems to me to present certain advantages, but, to prevent any difficulty which it might cause to British naturalists, I have placed the name of the authority for the species within brackets when the generic name has been changed.

In conclusion, I have to express my thanks to Professor

[1] Hoyle, Proc. Roy. Soc., Edinb., June 16, 1884.

F. Jeffrey Bell for some references and localities derived from the British Museum Collection; to the Rev. A. M. Norman, D.C.L., who supplied me with two species which I had overlooked, and also with a good deal of information from his own notes, which has been hitherto unpublished; and to Professor Steenstrup for the opportunity of examining the collection in the Copenhagen Museum.

ASTROPHYTIDÆ.

Asteronyx.

Asteronyx Lovéni, Müll. and Tr.

1842. *Asteronyx Lovéni*, Müll. and Tr., Syst. d. Aster., p. 119.
1861. „ „ Stewart, Ann. Nat. Hist., ser. 3, vol. viii., p. 77; Proc. Zool. Soc., p. 96.
1861. „ „ Sars, Overs. Norges Echin., p. 5, pl. i., figs. 1-5.
1865. „ „ Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 106.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 285.

Habitat. British Seas.—The Minch (H.M.S. "Porcupine," 1869); Loch Torridon, Ross-shire (Stewart); Aberdeen (G. Sim).[1]

Other Localities.—Norwegian coast (Sars); Finmark (Copenhagen Museum).

Gorgonocephalus.

Gorgonocephalus eucnemis, Lyman (Müll. and Tr.).

1780. *Asterias caput medusæ*, Fabricius, Fauna Groenlandica, No. 367.
1834. „ „ Dewhurst, Nat. Hist. Ord. Cetacea.
1842. *Astrophyton eucnemis*, Müll. and Tr., Syst. d. Aster., p. 123.
1858. „ „ Ltk., Addit. ad Hist., pt. i., p. 70, pl. ii., figs. 17-19.
1861. „ „ Sars, Overs. Norges Echin., p. 4.
1865. „ „ Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 181.
1877. „ „ Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 283.
1882. „ „ Hoffmann, Niederländ. Archiv f. Zool., Suppl.-Bd. i., Lief. 3, Echin., p. 2.
1882. *Gorgonocephalus eucnemis*, Lyman, Zool. Chall. Exp., pt. xiv., p. 263.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

[1] *Zoologist*, p. 24, 1882.

Habitat. British Seas.—Seven specimens of this species were dredged by H.M.S. "Triton," from one station in the warm area of the Faröe Channel; depth, 433 fathoms.

Other Localities.—Greenland, both eastern and western coasts (Lütken); "Valorous" Expedition (Norman);[1] North-East America (Lütken).

Gorgonocephalus Linckii, Lyman (Müll. and Tr.).

1733. *Astrophyton scutatum* (pars), Linck, De Stellis Marinis, pl. xix., No. 48.
1766. *Asterias caput medusæ* (?), Linné, Fauna Suecica, No. 2115.
1777. *Astrophyton arborescens*, Pennant (*non* Rondel, *nec* Müll. and Tr.), British Zoology, vol. iv., p. 67, No. 78.
1841. ,, *scutatum*, Forbes, British Starfishes, p. 67.
1842. ,, *Linckii*, Müll. and Tr., Syst. d. Aster., p. 122.
1865. ,, ,, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 190.
1865. ,, ,, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 105.
1882. *Gorgonocephalus Linckii*, Lyman, Zool. Chall. Exp., pt. xiv., p. 264.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Cornwall, Shetland, Orkney (Forbes); very rare.

Other Localities.—Norwegian coast to 150 fathoms (Sars, Norman).

OPHIURIDÆ.

AMPHIURA.

Amphiura bellis, Lyman, var. *tritonis*.

1882. *Amphiura bellis*, Lyman, Zool. Chall. Exp., pt. xiv., p. 127.
1884. ,, ,, var. *tritonis*, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—One specimen was dredged by H.M.S. "Triton," from a station in the warm area of the Faröe Channel; depth, 516 fathoms (Hoyle).

Other Localities.—Previously this species had only been found at three "Challenger" stations—one off the Fiji Islands, depth 210 to 610 fathoms, the specimens from which are marked "var. ?"; the other two near the coast of Japan; depths, 345 and 420 to 775 fathoms (Lyman).

[1] Proc. Roy. Soc., Lond., vol. xxv., p. 208, 1865.

Amphiura borealis, Lyman (Sars).

1871. *Ophiopeltis borealis*, Sars, Nye Echin., p. 16.
1882. *Amphiura* „ Lyman, Zool. Chall. Exp., pt. xiv., p. 144.

Habitat. British Seas.—One station on the border of the cold area of the Faröe Channel; depth, 203 fathoms.

Other Localities.—Lofoten Islands, 80 to 400 fathoms (Sars); Kors Fjord, Norway, 120 fathoms (Norman).

Amphiura Chiajii, Forbes.

1825. *Asterias filiformis*, Delle Chiaje, Mem. stor. anat. anim. Napoli, t. ii., p. 359.
1841. *Ophiocoma punctata*, Forbes, British Starfishes, p. 37 (Young ?).
1843. *Amphiura Chiajii*, *Id.*, Trans. Linn. Soc., Lond., vol. xix., p. 151, pl. xiv., figs. 14-18.
1843. „ *florifera* (?), *Id.*, *Ibid.*, p. 150.
1857. „ *Chiajii*, Sars, Middelhavets Litt. Fauna, p. 86.
1858. „ *Chiajei*, Ltk., Addit. ad Hist. Ophiurid., pt. i., p. 57, pl. ii., fig. 12.
1865. „ „ Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 119.
1865. „ „ Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 107.
1869. „ *Stepanovii*, Tscherniawsky, Protocol d. Moskauer Naturf. Versamml.
1879. „ *Chiajei*, Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 550.
1881. „ „ Leslie and Herdman, Proc. Roy. Phys. Soc., Edinb., vol. vi., p. 88.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 142.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Shetland, Durham, and Northumberland coasts, Clyde, Killary Sound, Ireland (Norman); Inveraray and Oban (D. Robertson); Hebrides (Forbes)[1]; Firth of Forth (Leslie and Herdman); Faröe Channel, Loch Linnhe (Hoyle). The species was dredged by H.M.S. "Triton" in the warm area of the Faröe Channel from 555 fathoms, the greatest depth hitherto recorded.

Other Localities.—Scandinavian coast (Sars), down to 200 fathoms (Norman); Black Sea (Tscherniawsky); Mediterranean, down to 100 fathoms (Ludwig); Trieste (Copenhagen Museum).

[1] Norman, *loc. cit.*, p. 108.

Amphiura filiformis, Forbes (O. F. Müller).

1776.	*Asterias filiformis*,		O. F. Müll., Zool. Dan. Prodr., p. 235.
1801.	*Ophiura*	,,	Lamck., Hist. anim. sans Vert., t. ii., p. 546.
1841.	*Ophiocoma*	,,	Forbes, British Starfishes, p. 40.
1842.	*Ophiolepis*	,,	Müll. and Tr., Syst. d. Aster., p. 94.
1843.	*Amphiura*	,,	Forbes, Trans. Linn. Soc., Lond., vol. xix., p. 151.
1857.	,,	,,	Sars, Middelhavets Litt. Fauna, p. 84.
1858.	,,	,,	Ltk., Addit. ad Hist. Ophiur., pt. i., p. 56, pl. ii., figs. 11 *a*, *b*.
1865.	,,	,,	Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 116.
1865.	,,	,,	Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 107.
1866.	,,	,,	Ljn., Oph. viv., p. 321.
1879.	,,	,,	Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 549.
1881.	,,	,,	Leslie and Herdman, Proc. Roy. Phys. Soc., Edinb., vol. vi., p. 88.
1882.	,,	,,	Lyman, Zool. Chall. Exp., pt. xiv., p. 144.
1884.	,,	,,	Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—"Shetland, Firth of Clyde, Durham and Northumberland coasts (Norman);"[1] Firth of Forth (Leslie and Herdman); Faröe Channel, warm area, 555 fathoms (Hoyle); Kenmare, Ireland (B. M. Coll.).

Other Localities.—Near Bukken, Norway, 20 fathoms (Norman); Mediterranean, 5-100 fathoms (Ludwig).

Amphiura securigera, Lyman (Düb. and Kor.).

1846.	*Ophiopeltis securigera*,		Düb. and Kor., Öfversigt Skand. Echin., p. 236, pl. vi., figs. 3-5.
1861.	,,	,,	Sars, Oversigt Norges Echin., p. 14.
1865.	,,	,,	Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 111.
1866.	,,	,,	Ljn., Oph. viv., p. 321.
1882.	*Amphiura*	,,	Lyman, Zool. Chall. Exp., pt. xiv., p. 148.

Habitat. British Seas.—This species was first dredged near our coasts by Dr Gwyn Jeffreys and the Rev. Dr Norman, "six miles to the north of the Whalsey Lighthouse, Shetland, in 40-50 fathoms,"[2] after which it was obtained by H.M.S. "Porcupine" in 1869.[3]

[1] Dr Norman's paper has in addition "Killary and other marine loughs of Connemara (Forbes)," but he now writes to me, "Since my paper was written I have been to Killary, and find that the *Amphiura*, which is very abundant there, is *A. Chiajei*, not *A. filiformis*."

[2] Norman, *loc. cit.*

[3] Depths of the Sea, p. 124; 1873, London.

Other Localities.—Hvidingsö, near Stavanger (Düb. and Kor.); near Bergen and Lofoten (Sars).

Amphiura elegans, Norman (Leach).

1815. *Ophiura elegans*, Leach, Zool. Miscell., vol. ii., p. 59.
1825. *Asterias squamata*, Delle Chiaje, Mem. stor. anat. anim. Napoli, vol. iii., p. 77, pl. xxxiv., fig. 1.
1835. *Ophiura neglecta*, Johnston, Mag. Nat. Hist., vol. viii., p. 467.
1840. ,, *moniliformis*, Grube, Aktin. Echin. u. Würm., p. 18.
1841. *Ophiocoma neglecta*, Forbes, British Starfishes, p. 30.
1842. *Ophiolepis squamata*, Müll. and Tr., Wiegmann, Archiv f. Naturgesch., vol. vi., p. 328; Syst. d. Aster., p. 92.
1845. *Amphiura neglecta*, Forbes, Trans. Linn. Soc., Lond., vol. xix., p. 150.
1851. *Ophiolepis tenuis*, Ayres, Proc. Bost. Soc. Nat. Hist., vol. iv., p. 133.
1857. ,, *squamata*, Sars, Middelhavets Litt. Fauna, p. 84.
1859. *Amphiura tenuis*, Lyman, Proc. Bost. Soc. Nat. Hist., vol. vii., p. 194.
1861. ,, *squamata*, Sars, Oversigt Norges Echin., p. 21.
1865. ,, *elegans*, Norman, Proc. Roy. Soc., vol. xxv., p. 215; Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 109.
1871. *Amphipolis* ,, Ltk., Vidensk. Meddel., p. 140.
1871. ,, *Kinbergi*, Ljn., Öfvers. K. Vetensk. Akad. Forhandl., p. 646.
1871. ,, *oppressa*, *Id.*, *Ibid.*, p. 647.
1871. ,, *lineata*, *Id.*, *Ibid.*, p. 634.
1880. *Amphiura neglecta*, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 201.
1881. ,, *squamata*, Leslie and Herdman, *Ibid.*, vol. vi., p. 88.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 136.

Habitat. British Seas.—On all coasts (Forbes, Norman); Scarborough (B. M. Coll.); Firth of Forth (Leslie and Herdman).

Other Localities.—Mediterranean, Scandivanian Coast (Norman); Cape of Good Hope, 98 fathoms; off S.E. Australia, 120 fathoms (Lyman); North-East America (Verrill).

Amphiura tenuispina, Ljn.

1864. *Amphiura tenuispina*, Ljn., Öfversigt K. Akad. Vetensk., p. 360.
1866. ,, *squamata* (var. ?), Ljn., Oph. viv., p. 313.
1868. ,, *tenuispina*, Norman, Last Shetland Dredging Report, Brit. Assoc. Rep., p. 340.
1871. *Amphipholis* ,, Ljn., Öfversigt K. Akad. Vetensk., p. 633.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 145.
1882. ,, *elegans*, var. *tenuispina*, Verrill, Amer. Journ. Sci. and Arts, vol. xxiii., p. 219.

Habitat. British Seas.—Shetland (Norman).

Other Localities.—Norway, 60-300 fathoms (Lyman) Hardanger and Christiania Fjords, 50-180 fathoms (Norman) North-East America, 120-487 fathoms (Verrill).

OPHIACANTHA.

Ophiacantha abyssicola, Sars.

1871. *Ophiacantha abyssicola*, Sars, Nye Echin., p. 8.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 199.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—The Faröe Channel, 203-458 fathoms ("Porcupine" Expedition).

Other Localities.—Bodö, 80-100 fathoms; Lofoten Islands, 120-300 fathoms (Sars).

Ophiacantha bidentata, Ljn. (Retz.).

1805. *Asterias bidentata*, Retz., Diss., p. 33.
1817. *Ophiura Retzii*, Nilsson, Collectanea Zoologiæ Scandinaviæ, p. 15.
1842. *Ophiacantha spinulosa*, Müll. and Tr., Syst. d. Aster., p. 107.
1842. *Ophiocoma arctica*, *Id.*, *Ibid.*, p. 103.
1844. *Ophiacantha grönlandica*, *Id.*, Archiv f. Naturgesch., p. 183.
1852. *Ophiocoma echinulata*, Forbes, Sutherland's Journ. Voy. Baffin's Bay, vol. ii., p. ccxv. (App.).
1858. *Ophiacantha spinulosa*, Ltk., Addit. ad. Hist., pt. i., p. 65, pl. ii., fig. 14.
1861. „ „ Sars, Oversigt Norges Echin., p. 13.
1865. „ „ Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 93, figs. 6, 7.
1871. „ *bidentata*, Ljn., Öfversigt K. Akad. Vetensk., p. 652.
1877. „ *spinulosa*, Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 282.
1881. „ „ Duncan and Sladen, Mem. Echin. West Greenl., p. 68.
1882. „ *bidentata*, Lyman, Zool. Chall. Exp., pt. xiv., p. 186.
1882. „ „ *Id.*, Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1882. „ *spinulosa*, Hoffmann, Niederländ. Archiv f. Zool., Suppl.-Bd. i., Lief. 3, Echin., p. 3.
1883. „ „ Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 260.
1884. „ *bidentata*, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—This species has been obtained in both areas of the Faröe Channel at depths varying from 203 to 515 fathoms (Lyman, Hoyle).

Other Localities.—Three "Challenger" and eight "Blake"

stations off the east coast of North America, depths 83 to 1350 fathoms (Lyman); Scandinavian coast, 20-180 fathoms (Sars, Norman); Barents Sea (Hoffmann); Spitzbergen, Finmark, both east and west coasts of Greenland, 20-85 fathoms (Lütken, Duncan and Sladen); North Atlantic, 2435 fathoms (H.M.S. "Porcupine," 1869).[1]

Ophiacantha spectabilis, Sars.

1871. *Ophiacantha spectabilis*, Sars, Nye Echin., p. 10.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 198.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Faröe Channel, one station in the warm area; depth, 433 fathoms (Hoyle).

Other Localities.—Bodö, coast of Norway, 80-100 fathoms (Sars).

OPHIACTIS.

Ophiactis abyssicola, Ljn. (Sars).

1861. *Amphiura abyssicola*, Sars, Oversigt Norges Echin., p. 18.
1865. *Ophiocnida* ,, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 12.
1866. *Ophiactis* ,, Ljn., Oph. viv., p. 324.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 122.
1882. ,, ,, *Id.*, Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1884. ,, ,, Hoyle, *Ibid.*, June 16.

Habitat. British Seas.—This species has hitherto been recorded only from the Faröe Channel, from eight stations in the warm area; depths, 433 to 767 fathoms; and from four stations in the cold area, depths 327 to 384 fathoms (Lyman, Hoyle); as well as from two "Porcupine" stations east of the Shetlands, depths 64 and 75 fathoms (Hoyle).

Other Localities.—Off Aalesund and Lofoten (Sars); near Bukken and in the Hardanger Fjord, 80-110 fathoms (Norman); 8 miles from Storeggen, 400 fathoms (Copenhagen Museum).

Ophiactis Ballii, Ltk. (Thomps.).

1840. *Ophiocoma Ballii*, Thompson, Ann. and Mag. Nat. Hist., vol. v., p. 99.
1841. ,, *Goodsiri*, Forbes, British Starfishes, p. 57.
1842. *Ophiolepis Ballii* and *Goodsiri*, Müll. and Tr., Syst. d. Aster., p. 97.
1848. *Ophiopolis* ,, ,, Gray, Brit. Mus. Cat., p. 25.

[1] Depths of the Sea, p. 97; 1873, London.

1857. *Amphiura Ballii*, Sars, Middelhavets Litt. Fauna, p. 99.
1859. *Ophiactis* „ Ltk., Addit. ad. Hist., pt. ii., p. 126.
1861. *Amphiura* „ Sars, Oversigt Norges Echin., pp. 17, 20.
1865. „ „ Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 109.
1865. *Ophiocnida* „ Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 12.
1882. *Ophiactis* „ *Id.*, Zool. Chall. Exp., pt. xiv., p. 121.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Shetland; "off the coasts of Durham and Northumberland (Norman); Moray Firth (Mr T. Edward); Dublin (Dr Ball);"[1] Anstruther (Forbes Coll. B. M.); Faröe Channel, both warm and cold areas, in the former of which it was dredged by H.M.S. "Porcupine" from a depth of 363 fathoms; very rare.

Other Localities.—Scandinavian coast (Düben and Koren), down to 190 fathoms (Norman); North Atlantic, depth 40 to 50 fathoms (Lyman).

OPHIOBYRSA.

Ophiobyrsa hystricis, Lyman.

1883. *Ophiobyrsa hystricis*, Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 272.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Hitherto this species has only been dredged at one station in the cold area of the Faröe Channel from a depth of 345 fathoms. It is mentioned by Sir Wyville Thomson in his account of the "Porcupine" cruise as being nearly allied to *Ophiomyxa*, but no name is given to it.[2]

Other representatives of the genus are found off Australia and the West Indies (Lyman).

OPHIOCHITON.

Ophiochiton tenuispinus, Lyman.

1883. *Ophiochiton tenuispinus*, Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 255, pl. v., figs. 67-69.

[1] Norman, *loc. cit.*
[2] Depths of the Sea, p. 123; 1873, London.

Habitat. British Seas.—One specimen of this species was dredged at one station in the "Porcupine" Expedition of 1869, south-west of Ireland, 862 fathoms.

Other Localities.—None.

"The genus is new to north European waters" (Lyman). Hitherto only two species have been described—one, *O. fastigatus*, from the *Hyalonema*-ground south of Japan, 345 fathoms, and from the south-west of Papua, 800 fathoms; the other, *O. lentus*, from 600 fathoms, near the Kermadec Islands.[1]

OPHIOCNIDA.

Ophiocnida brachiata, Lyman (Montagu).

1804. *Asterias brachiata*, Montagu, Trans. Linn. Soc. Lond., vol. vii., p. 84.
1841. *Ophiocoma* ,, Forbes, British Starfishes, p. 45.
1842. *Ophiolepis* ,, Müll. and Tr., Syst. d. Aster., p. 96.
1857. *Amphiura Neapolitana*, Sars, Middelhavets Litt. Fauna, p. 91, pl. i., figs. 11-15.
1859. ,, ,, Ltk., Addit. ad Hist., pt. ii., p. 114.
1859. ,, *brachiata*, *Id.*, *Ibid.*
1865. ,, ,, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 109.
1865. *Ophiocnida neapolitana*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 12.
1865. ,, *brachiata*, *Id.*, *Ibid.*
1866. ,, ,, Ljn., Oph. viv., p. 317.
1879. ,, ,, Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 550.
1881. ,, ,, Leslie and Herdman, Proc. Roy. Phys. Soc., Edinb., vol. vi., p. 89.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 155.

Habitat. British Seas.—Salcombe Bay[2] (Montagu); Coast of Down and Antrim (Thompson); Firth of Forth (Leslie and Herdman).

Other Localities.—Mediterranean (Sars), 20 fathoms (Ludwig); North European Seas (Lyman).

[1] Lyman, Zool. Chall. Exp., pt. xiv., pp. 176-178.

[2] Buried in the sand in pools at extreme low-water spring tides, the tips of the arms only appearing above the surface. I went to Salcombe in 1876 for the special purpose of rediscovering this and one or two other of Montagu's species in that locality (Norman).

Ophiocoma.

Ophiocoma nigra, Mull. and Tr. (O. F. Mull.).

1789. *Asterias nigra*, Müller, Zool. Dan., vol. iii., p. 20, pl. xciii., figs. 1 4.
1828. *Ophiura granulata*, Fleming, British Animals, p. 488.
1840. *Ophiocoma nigra*, Müll. and Tr., Archiv f. Naturgesch., p. 328.
1841. „ *granulata*, Forbes (*non* Linck), British Starfishes, p. 50.
1842. „ *Nilsoni*, Mull. and Tr., Syst. d. Aster., p. 100.
1842. „ *nigra*, *Id.*, *Ibid.*
1865. „ „ Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 81.
1865. „ „ Norman, Ann and Mag. Nat. Hist., ser. 3, vol xv., p. 111.
1880. „ „ Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 201.
1881. „ „ Leslie and Herdman, *Ibid.*, vol. vi., p. 83.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 172. *Id.*, Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1882. „ „ Hoffmann, Niederland. Archiv f. Zool. Suppl.-Bd. i., Lief. 3, Echin., p. 4.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Shetland and other localities on British shore, "open sea and salt water lochs in from 7 to 30 fathoms water" (Forbes); Lamlash Bay, Arran, Firth of Forth (Leslie and Herdman); Faröe Channel, 53 fathoms (Lyman), 87 fathoms (Hoyle); Falmouth (B. M. Coll.).

Other Localities.—Scandinavia (Sars); Bergen and Christiania (Copenhagen Museum); North European Seas (Lyman); Barents Sea (Hoffmann).

Ophiocten.

Ophiocten sericeum, Ljn. (Forbes).

1852. *Ophiura sericea*, Forbes, Sutherland's Journ. Voy. Baffin's Bay, vol. ii., p. ccxv. (App.).
1854. *Ophiocten kröyeri*, Ltk., Vidensk. Meddel., p. 102.
1858. „ „ *Id.*, Addit. ad Hist., pt. i., p. 52, pl. i., figs. 5a-5d.
1864. „ *sericeum*, Ljn., Öfversigt K. Akad. Vetensk., p. 360.
1865. „ *kröyeri*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 53.
1877. „ „ Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 282.
1878. „ *sericeum*, Lyman, Bull. Mus. Comp. Zool., vol. v., No. 7, p. 102.
1881. „ „ Duncan and Sladen, Mem. Echin. West Greenl., p. 65.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 79.
1882. „ „ Hoffmann, Niederländ. Archiv f. Zool., Suppl.-Bd. i., Lief. 3, Echin., p. 3.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—One station in warm area of the Faröe Channel; depth, 542 fathoms.

Other Localities.—Both eastern and western coasts of Greenland (Duncan and Sladen, Lütken); Spitzbergen (Lütken); Barents Sea (Hoffmann); Hardanger Fjord, Norway, 180 fathoms (Norman); North Atlantic, 2435 fathoms (H.M.S. "Porcupine," 1869).[1]

OPHIOGLYPHA.

Ophioglypha affinis, Lyman (Ltk.).

1858. *Ophiura affinis*, Ltk., Addit. ad Hist., pt. i., p. 45, pl. ii., figs. 10 *a*, *b*.
1862. „ *Grubei*, Heller, Lit. Fauna d. Adriat. Meeres, p. 431, pl. ii., figs. 13-16.
1863. „ *Normanni*, Hodge, Trans. Tyneside Nat. F. Club, vol. v., pt. 4, p. 296.
1865. „ *affinis*, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 113.
1865. *Ophioglypha affinis*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 52.
1879. „ „ Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 547.
1881. „ „ Leslie and Herdman, Proc. Roy. Phys. Soc., Edinb., vol. vi., p. 87.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 77.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Firth of Clyde, Shetland, Northumberland coasts (Norman); Firth of Forth (Leslie and Herdman).

Other Localities.—Mediterranean (Ludwig, Heller); Norwegian and Danish coasts (Lütken, Norman); North-East America (Lyman).

The greatest depth hitherto recorded for this species appears to be 192 fathoms (Lyman).

Ophioglypha albida, Lyman (Forbes).

1816. *Ophiura texturata* (pars), Lamck., Hist Anim. sans Vert., vol. ii., p. 542.
1829. „ *albida*, Forbes, Mem. Wern. Soc., vol. viii., p. 125, pl. iv., figs. 5, 6.
1841. „ „ *Id.*, British Starfishes, p. 27.
1858. „ „ Ltk., Addit. ad Hist., pt. i., p. 39, pl. i., figs. 2 *a*, *b*.
1865. „ „ Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 113.

[1] Depths of the Sea, p. 97; 1873, London.

1865. *Ophioglypha albida*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 49.
1880. ,, ,, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 200.
1881. ,, ,, Leslie and Herdman, *Ibid.*, vol. vi., p. 87.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 76.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—"Every part of our coast" (Norman); Firth of Forth, Lamlash Bay, Arran (Leslie and Herdman); Faröe Channel, 458 fathoms (Hoyle).

Other Localities.—Sound (Copenhagen Museum); North European Seas, Mediterranean, 5-250 fathoms (Lyman); Norway, common (Norman).

Ophioglypha aurantiaca, Verrill.[1]

1882. *Ophioglypha aurantiaca*, Verrill, Amer. Journ. Sci. and Arts, vol. xxiii., p. 141.
1882. ,, ,, Lyman, Proc. Roy. Soc., Edinb., vol. xi., p 707.
1883. ,, ,, *Id.*, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 290, with fig.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Faröe Channel at four stations, all in the warm area, depth 516-570 fathoms (Lyman, Hoyle).

Other Localities.—Off Martha's Vineyard, North-East America, 192-310 fathoms (Verrill).

Ophioglypha lacertosa, Lyman (Pennant).

1733. *Stella lumbricalis lacertosa*, Linck, De Stell. Marin., pl. ii., No. 4, p. 47.
1766. *Asterias ophiura*, O. F. Müll., Zool. Dan. Predr., p. 235.
1777. ,, *lacertosa*, Pennant, British Zoology, vol. iv., p. 63.
1805. ,, *ciliata*, Retz., Diss. Syst. sp. cogn. Aster., p. 29.
1816. ,, *texturata* (pars), Lamck., Hist. Anim. sans Vert., p. 542.
1825. ,, *cordifera*, Delle Chiaje, Mem. stor. anat. anim., vol. ii., p. 358, pl. xx., fig. 12.
1826. ,, *aurora*, Risso, Hist. Nat., vol. v., p. 273, fig. 29.
1829. ,, *texturata*, Forbes, Mem. Wern. Soc., vol. viii., p. 125, pl. iv., figs. 3, 4.
1835. ,, *bracteata* (?), Johnst., Mag. Nat. Hist., vol. viii., p. 467.
1841. *Ophiura texturata*, Forbes, British Starfishes, p. 22.
1842. *Ophiolepis ciliata*, Müll. and Tr., Syst. d. Aster., p. 91.
1858. *Ophiura texturata*, Ltk., Addit. ad Hist., pt. i., p. 36, pl. i., figs. 1*a*-1*e*.

[1] This species has since been referred to the genus *Ophiopleura* by the original describer (Amer. Journ. Sci. and Arts, vol. xxiii., pp. 218, 248, 1882).

1865. *Ophiura lacertosa*, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 112.
1865. *Ophioglypha* ,, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 40.
1879. ,, ,, Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 546.
1880. ,, ,, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 200.
1881. ,, ,, Leslie and Herdman, *Ibid.*, vol. vi., p. 67.
1882. ,, *ciliata*, Lyman, Zool. Chall. Exp., pt. xiv., p. 76.
1882. ,, ,, Hoffmann, Niederländ. Archiv f. Zool. Suppl.-Bd. i., Lief. 3, Echin., p. 6.
1883. ,, ,, Bell, Journ. Linn. Soc., vol. xvii., p. 103.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—"All round our coasts" (Norman); Firth of Forth, Lamlash Bay, Arran (Leslie and Herdman).

Other Localities.—North European Seas; Mediterranean (Lyman); Western America (?); near Dröbak, Norway (Norman); Madeira (B. M. Coll.).

The "Willem Barents" investigations have extended the distribution of this species to the Arctic seas of Europe and Asia.

Ophioglypha robusta, Lyman (Ayres).

1851. *Ophiolepis robusta*, Ayres, Proc. Boston Soc. Nat. Hist., vol. iv., p. 134.
1854. *Ophiura fasciculata*, Forbes, Sutherland's Journ. Voy. Baffin's Bay, vol. ii., p. ccxiv. (App.).
1854. ,, *squamosa*, Ltk., Vidensk. Meddel., p. 100.
1857. ,, ,, *Id.*, Overs. Grönl. Echin., p. 50.
1858. ,, ,, *Id.*, Addit. ad. Hist., pt. i., p. 46, pl. i., fig. 7 *a*, *b*.
1865. ,, ,, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 114.
1865. *Ophioglypha robusta*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 45.
1877. ,, ,, Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 282.
1881. ,, ,, Duncan and Sladen, Mem. Echin. West Greenl., p. 62.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 77.
1882. ,, ,, Hoffmann, Niederländ. Archiv f. Zool. Suppl.-Bd. i., Lief. 3, Echin., p. 5.

Habitat. British Seas.—East coast of northern England and Scotland (Norman).

Other Localities.—Sound (Copenhagen Museum); both coasts of Greenland, 20-80 fathoms (Lütken, Duncan and Sladen); Spitzbergen and Barents Sea (Hoffmann); Finmark

(Lütken); Christiania Fjord and West Norway, 14-180 fathoms (Norman); North-East America (Lyman).

Ophioglypha Sarsii, Lyman (Ltk.).

1854. *Ophiolepis ciliata*, Stimps., Smithson. Contrib., vol. vi., p. 13.
1854. *Ophiura coriacea*, Ltk., Vidensk. Meddel., p. 101.
1854. „ *Sarsii*, *Id.*, *Ibid.*
1858. „ „ *Id.*, Addit. ad Hist., pt. i., p. 42, pl. i., figs. 3, 4.
1865. „ „ Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 113.
1865. *Ophioglypha Sarsii*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 41, figs. 2, 3.
1877. „ „ Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 282.
1881. „ „ Duncan and Sladen, Mem. Echin. West Greenl., p. 60.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 40.
1882. „ „ Hoffmann, Niederland. Archiv f. Zool. Suppl.-Bd. i., Lief. 3, Echin., p. 6.
1883. „ „ Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 240.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Shetland, 80-100 fathoms (Norman); Faröe Channel, cold area, 345 fathoms (Hoyle).

Other Localities.—Barents Sea, down to 210 fathoms (Hoffmann); American and European Coasts of Greenland, 10, 20, 35 fathoms (Lütken, Duncan and Sladen); Spitzbergen, Finmark; Norwegian coast, 60-200 fathoms (Norman). "A very characteristic cold-water species" (Lütken). At one "Challenger" station, off east coast of North America, 83 fathoms; at four "Blake" stations in the same region, 44 to 306 fathoms (Lyman), down to 358 fathoms (Verrill).[1]

Ophioglypha signata, Verrill.

1880. *Ophioglypha signata*, Verrill, Amer. Journ. Sci. and Arts, vol. xxiii., p. 220.
1882. „ „ Lyman, Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1884. „ „ Hoyle, *Ibid.*, June 16.

Habitat. British Seas.—Faröe Channel, four stations in the cold, and one in the warm area, 327 to 640 fathoms (Lyman, Hoyle).

Other Localities.—North-East America, Gulf of Maine, Bay of Fundy, off Nova Scotia, 100-258 fathoms (Verrill).

[1] Amer. Journ. Sci. and Arts, vol. xxiii., p. 218, 1882.

OPHIOMUSIUM.

Ophiomusium Lymani, Wyv. Thoms.

1873. *Ophiomusium Lymani*, Wyville Thomson, Depths of the Sea, pp. 100, 173, figs. 32, 33; London.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 90.
1882. ,, ,, Verrill, Amer. Journ. Sci. and Arts, vol. xxiii., p. 219.

Habitat. British Seas.—Off the south-west of Ireland, 180 fathoms; warm area of the Faröe Channel (Thomson).

Other Localities.—East coast of North America (Verrill, Lyman); near the Azores, 900 fathoms; off Tristan da Cunha, north of New Zealand, south of Papua, off Japan, South Pacific, 1825 fathoms (Lyman).

OPHIOMYXA.

Ophiomyxa serpentaria, Lyman.

1883. *Ophiomyxa serpentaria*, Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 274.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Only one specimen of this species has yet been obtained, viz., by H.M.S. "Porcupine," in the cold area of the Faröe Channel; depth, 363 fathoms (Lyman).

OPHIOPHOLIS.

Ophiopholis aculeata, Gray (O. F. Müll.).

1733. *Bellis scolopendrica*, Linck, De Stell. Marin., p. 52, pl. xl., fig. 71.
1776. *Asterias aculeata*, O. F. Müll., Zool. Dan. Prodr., p. 235, No. 2841½.
1780. ,, *ophiura*, Fabr., Fauna Groenl., p. 371.
1783. ,, *aculeata*, Retz., Asteriæ Gen., p. 240.
1788. ,, ,, Linné, Syst. Nat., Ed. xiii. (Gmel.), p. 3166.
1789. ,, ,, O. F. Müll., Zool. Dan., p. 29, pl. xcix.
1817. *Ophiura flemingii et O. ammothea*, Leach, Zool. Miscell., vol. ii., pp. 55, 56, pl. lxxix., figs. 1-3.
1828. ,, *bellis*, Fleming, Edin. New. Phil. Jour., vol. viii., p. 298.
1828. ,, ,, *Id.*, British Animals, p. 488.
1829. *Ophiocoma bellis*, Forbes, Mem. Wern. Soc., Edinb., vol. viii., p. 126.
1835. *Ophiura* ,, Johnst., Mag. Nat. Hist., p. 595.
1840. *Ophiolepis* (*Ophiopholis*) *scolopendrica*, Müll. and Tr., Archiv f. Naturgesch., p. 328.
1841. *Ophiocoma bellis*, Forbes, British Starfishes, p. 53.
1842. *Ophiolepis* (*Ophiopholis*) *scolopendrica*, Müll. and Tr., Syst. d. Aster., p. 96.

1858. *Ophiopholis aculeata*, Ltk., Addit. ad Hist., pt. i., p. 60, pl. ii., figs. 15, 16.
1865. „ *bellis*, Lyman, Ill. Cat. Mus. Comp. Zool., No. i., p. 96, pl. i., figs. 4-6.
1865. „ *aculeata*, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 112.
1877. „ „ Marenzeller, Denkschr. d. k. Akad. Wiss. Wien, Bd. xxxv., p. 283.
1880. „ *bellis*, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 201.
1881. „ „ Leslie and Herdman, *Ibid.*, vol. vi., p. 67.
1882. „ *aculeata*, Lyman, Zool. Chall. Exp., pt. xiv., p. 112; Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1882. „ „ Hoffmann, Niederländ. Archiv f. Zool. Suppl.-Bd. i., Lief. 3, Echın., p. 5.
1883. „ „ Bell, Journ. Linn. Soc., Lond., vol. xvii., p. 103.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—All round our coasts, but scarcer in the south (Norman); Isle of Man (B. M. Coll.); Firth of Cromarty (Copenhagen Museum). It was found by the "Knight Errant" and "Triton," in the Faröe Channel; depths, 53 to 560 fathoms (Lyman, Hoyle). It appears to be rather more abundant in the shallower waters.

Other Localities.—Norwegian coast, down to 200 fathoms (Norman); Barents Sea (Hoffmann); Spitzbergen (Lütken); eastern and western shores of Greenland (Lütken, Duncan and Sladen). It has been dredged off the north-east coast of North America, both by the "Blake"[1] and the "Challenger;" depths from 80 to 300 fathoms.

OPHIOPSILA.

Ophiopsila annulosa, Ltk. (M. Sars).

1857. *Ophianoplus annulosus*, Sars, Middelhavets Litt. Fauna, p. 88, pl. i., figs. 2-7.
1859. *Ophiopsila annulosa*, Ltk., Addit. ad Hist., pt. ii., p. 136.
1869. „ „ Brady, Ann. and Mag. Nat. Hist., ser. 4, vol. iii., pl. xxii., figs. 1-6.
1879. „ „ Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 551.
1882. „ „ Lyman, Zool. Chal. Exp., pt. xiv., p. 160.

Habitat. British Seas.—Birterbury Bay (Norman); Kenmare Bay (More, *fide* Norman).

Other Localities.—Mediterranean (Sars, Ludwig).

[1] Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 249, 1883.

OPHIOPUS.

Ophiopus arcticus, Ljn.

1866. *Ophiopus arcticus*, Ljn., Oph. viv., p. 309.
1872. *Ophiaregma abyssorum*, Sars, Nye Echin., p. 42.
1875. *Ophiopus arcticus*, Ltk., *in* Arctic Manual, p. 185.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 156.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—This arctic species was taken by H.M.S. "Porcupine" at one station in the cold area of the Faröe Channel; depth, 384 fathoms.

Other Localities.—Spitzbergen, Norway, 400 fathoms (Lyman); Greenland (Lütken).

OPHIOSCOLEX.

Ophioscolex glacialis, Müll. and Tr.

1842. *Ophioscolex glacialis*, Müll. and Tr., Syst. d. Aster., p. 109.
1861. „ „ Sars, Oversigt Norges Echin., p. 7.
1882. „ „ Lyman, Zool. Chall. Exp., pt. xiv., p. 234.
1882. „ „ *Id.*, Proc. Roy. Soc., Edinb., vol. xi., p. 707.
1882. „ „ Hoffmann, Niederländ. Archiv f. Zool., Suppl.-Bd. i., Lief. 3, Echin., p. 3.
1883. „ „ Lyman, Bull. Mus. Comp. Zool., vol. x., No. 6, p. 268.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Three stations in the Faröe Channel (cold area); depths, 290-375 fathoms (Lyman, Hoyle).

Other Localities.—Scandinavian coast (Sars, Düben and Koren); Barents Sea (Hoffmann); Greenland (Lütken);[1] Spitzbergen (Lütken). One "Blake" dredging off the east coast of North America; depth, 197 fathoms (Lyman); New England coast, 115-238 fathoms (Verrill).[2]

Ophioscolex purpureus, Düben and Koren.

1846. *Ophioscolex purpureus*, Düb. and Kor., Öfvers. Skand. Echin., p. 235.
1866. „ „ Ljn., Oph. viv., p. 327.
1878. „ „ Lyman, Bull. Mus. Comp. Zool., vol. v., pt. 9, p. 233.
1882. „ „ *Id.*, Zool. Chall. Exp., pt. xiv., p. 234.
1884. „ „ Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—Five stations in the warm area of

[1] Arctic Manual, p. 185, 1875.
[2] Amer. Journ. Sci. and Arts, vol. xxiii., p. 219, 1882.

the Faröe Channel, depths 64 to 767 fathoms, and one station in the cold area, depth 632 fathoms (Hoyle).

Other Localities.—Coast of Norway (Sars); Hardanger Fjord, 100-200 fathoms (Norman); West Indies, 190 fathoms (Lyman).

OPHIOTHRIX.

Ophiothrix fragilis, Düb. and Kor. (O. F. Müll.).

1789. *Asterias fragilis*, Müll., Zool. Dan., vol. iii., p. 28, pl. xcviii.
1842. *Ophiothrix Rammelsbergii*, Müll. and Tr., Syst. d. Aster., p. 113, pl. viii., fig. 3.
1842. ,, *fragilis*, *Id.*, *Ibid.*, p. 110, pl. ix., fig. 2.
1846. ,, ,, Düb. and Kor., Öfvers. Skand. Echin., p. 238.
1857. ,, *alba* (?), Grube, Archiv f. Naturg., p. 344.
1865. ,, *fragilis*, Norman, Ann. and Mag. Nat. Hist., ser. 3, vol. xv., p. 107.
1869. ,, ,, (pars), Ltk., Addit. ad Hist., pt. iii., p. 52.
1874. ,, ,, Lyman, Bull Mus. Comp. Zool., vol. iii., pt. 10, p. 249.
1879. ,, ,, Ludwig, Mittheil. d. zool. Stat. Neapel, Bd. i., p. 551.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 224.
1884. ,, ,, Hoyle, Proc. Roy. Soc., Edinb., June 16.

Habitat. British Seas.—All round our coast (Norman); Faröe Channel, two stations in the warm area, depths 87 and 516 fathoms (Hoyle).

Other Localities.—Scandinavia (Düben and Koren); North Sea (Copenhagen Museum); Mediterranean (Ludwig).

Ophiothrix Lütkeni, Wyv. Thoms.

1873. *Ophiothrix Lütkeni*, Wyville Thomson, Depths of the Sea, p. 100, London.
1882. ,, ,, Lyman, Zool. Chall. Exp., pt. xiv., p. 218.

Habitat. British Seas.—Off the south-west coast of Ireland, 180 fathoms (Thomson).

Other Localities.—Near the Azores, 450 fathoms (Lyman).

Ophiothrix pentaphyllum, Ljn. (Pennant).

1812. *Asterias pentaphyllum*, Pennant, British Zoology, vol. iv., pp. 54, 55.
1841. *Ophiocoma rosula*, Forbes, British Starfishes, p. 60.
1871. *Ophiothrix pentaphyllum*, Ljn., Öfvers. K. Akad. Vetensk., p. 622.
1874. ,, ,, Lyman, Bull. Mus. Comp. Zool., vol. iii., pt. 10, p. 249.
1880. ,, *rosula*, Herdman, Proc. Roy. Phys. Soc., Edinb., vol. v., p. 200.
1881. ,, ,, Leslie and Herdman, *Ibid.*, vol. vi., p. 89.

1882. *Ophiothrix pentaphyllum*, Lyman, Zool. Chall. Exp., pt. xiv., p. 225.
1882. ,, ,, *Id.*, Proc. Roy. Soc., Edinb., vol. xi., p. 707.

Habitat. British Seas.—All parts of the coast (Forbes); Firth of Forth, Lamlash Bay, Arran (Leslie and Herdman); Faröe Channel, 53 fathoms (Lyman).

Other Localities.—North and west of France (Lyman).

There is some little doubt about the distribution of this species, as Forbes and Norman do not distinguish between it and *O. fragilis*.

Lyman, in his "Challenger Report," gives its British distribution as "south of England," but there can be no doubt about the specimens which he identified from the "Knight Errant" dredgings.

The above list contains thirty-seven species (three belonging to the family Astrophytidæ), whence it appears that the number of Ophiuroids known to inhabit British Seas has more than doubled during the past twenty years.

It may also be remarked that the only species which have been found nowhere else than in British Seas are three (*Ophiobyrsa hystricis, Ophiochiton tenuispinus*, and *Ophiomyxa serpentaria*), which were dredged by H.M.S. "Porcupine" at isolated points in the Faröe Channel. Perhaps *Ophiothrix pentaphyllum* should be added to these, as its "other localities" belong to the same zoological province as the British Seas, viz., north and west of France.

XV. *On the Silver Districts of Colorado (Leadville and San Juan).* By Henry Gunn, Esq., Assoc.R.S.M., etc.

(Read 23d April 1884.)

Abstract.

In the first portion of the paper, which dealt with the Leadville deposits, the author pointed out that within a limited thickness of from 700 to 1000 feet, typical representatives of Laurentian, Cambrian, Silurian, and Carboniferous rocks were to be found, and also indicated the influence which intrusive rocks had in the exposition of the mineral veins, as all the deposits occurred at the contact of the quartz porphyry with the limestones. Specimens illus-

trative of the ores mined in the district were exhibited; also some possessing unusual associations of minerals—a specimen, showing granules of free gold in hard carbonate of lead, attracting much attention, from the fact that it was the only specimen ever discovered in the district exhibiting this conjunction. Mr Gunn exhibited specimens of tellurium ores of remarkable beauty, and a sample of zinc blende mined in large quantity in Pitkin County, which, contrary to the opinion generally held by miners, contained large quantities of silver. The second portion of the paper dealt with the San Juan district, and, after indicating the peculiar disadvantages under which this district laboured for the first few years of its existence, proceeded to describe its geology, which he stated to be Trachyte, overlying rocks of Carboniferous and Devonian age. The mineral is found in true fissure veins of great width, chiefly composed of quartzose matter, but usually carrying one or more grey streaks, from two to six feet wide, composed of galena, fahlerz, and sulphurets of silver and gold. Some of the mines produce beautiful filaments of native silver, and one of the specimens showed a very unusual association—viz., fine filaments of silver on grey copper.

XVI. *On Boulder-Glaciation.* By Hugh Miller, Esq., A.R.S.M., F.G.S., Honorary Member of the Tyneside Field Club. [Plate VI.]

(Read 23d April 1884.[1])

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,, ,, near Edinburgh.

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[1] Part II. has been entirely written *since* this date. An abstract of this part (on Fluxion-Structures) has been communicated to the meeting of the British Association at Montreal.

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Introduction.

The boulder-clay has long been considered a formation *sui generis*. Its indiscriminate assemblage of materials of all sorts and sizes and weights is the fact that seems first to have struck the earlier observers of this singular deposit. It was totally unlike any stratified deposit of which they had experience. It had undergone no sifting or assortment, either in the powdered matter that constituted its matrix, or in the miscellaneous boulders that were flung as if at random all through. Poor Robert Dick, working all alone up at Thurso, seems almost to have got angry with its peculiarities. It differs entirely, says he, "from every other thing on the earth's surface. It is not a conglomerate. It would never, though consolidated, form a bed similar to conglomerate. It is not a production of the Mosaic deluge. It is not, strictly speaking, a production of the sea. It is not the sweepings of a sea shore. No! nothing of the kind. No Mosaic deluge could have produced these beds of dark stony clay. No ocean waves alone, by the friction of ten thousand years on rocky strata, could have done it. No! Tens and hundreds of millions of steam-mills, grinding stones night and day for a thousand years, could not have done it. No sea casts up anything like it. It is a distinct, generic production, fairly entitled to a place by itself."

The Boulder-Clay not Structureless.

The apparently random character of the formation, however, has too often led geologists to consider it as structureless. "The boulder-clay," says Professor Hull, "is entirely

structureless."[1] "Save with some rare exceptions," says Mr Archibald Geikie, "its boulders are not arranged in any determinate manner."[2] "Typical till," says Professor Green, "is a tough, dense clay . . . stuck as full as it can hold of stones of all sizes, which are not arranged in any order, but look as if they had been forcibly rammed in anyhow."[3]

Good till greatly resembles one of these concretes in which stones and shingle of many shapes and sizes have been thrust into a paste of soft asphalt. Now, in a pavement of this kind, we might expect, in favourable circumstances, to find certain structures. If the pavement had been repaired or patched by simply placing a new concrete here and there upon the top of the old, we should find inside it groups of stones with their upper surfaces worn down by the traffic, or perhaps grooved, after the manner of some of our street causeways, by the passage of wheels. Again, if the asphalt had been placed upon a slope, and in a too pasty condition, it might have made of itself a sort of miniature glacier—such as Sir William Thomson, I am informed, occasionally exhibits to his class at Glasgow. And having been in motion, we might expect to find a rude sort of fluxion-structure developed, comparable to that which is found among certain igneous rocks.

Both these structures are characteristic of the boulder-clay in a degree hitherto not much noticed; and it is to the facts respecting them that I devote this paper. They will be found to bear shrewdly upon its origin.

I.—Glaciation of the Upper Surfaces of Boulders *in situ*.—Pavement-Boulders.

The earliest observations upon the glaciation of boulders *in situ* in the till of which I am aware were recorded by Charles Maclaren in the *Scotsman* in 1828,[4] as having been

[1] Phys. Geol. and Geog. of Ireland, p. 79.

[2] On the Glacial Drift of Scotland (Trans. Geol. Soc., Glasgow, vol. i., part 2, p. 41).

[3] Geology for Students, 2d ed., p. 263.

[4] In a leading article upon Sir James Hall's celebrated paper "On the Revolutions of the Earth's Surface." See Maclaren's Geology of Fife and the Lothians, 2d edit., p. 290.

made by him in railway cuttings near Edinburgh. "In examining some of the blocks of larger size," he says, "we find the *upper surface* and two of the sides finely dressed, while the lower surface and the two ends are either much less dressed or actually rough and angular. It is remarkable," he continues, "that *in such stones, though lying at a great distance from one another*, we find the direction of these fine groovings which constitute dressing *generally to correspond*, and to point in a direction E. and W. (*i.e.*, the direction of the rock-striæ in the district). . . . This cannot well be explained on any other supposition than that their surface had been subjected in the position they now occupy to the smoothing action of hard substances rolled by a current of water from the west. . . . Some of the larger blocks are polished *on the upper and not on the under side.* This evidently shows that *the clay did not close round them at once*, but that, after the part below was firm, the current above, bearing other clay and stones with it, was still in motion."

Ten years later, Mr Milne Home's notice was attracted by certain boulders striated *in situ* on the shore at Joppa. He suggested that similar observations should be made wherever possible.[1] In 1845 and 1848, Mr Smith of Jordanhill observed parallel striæ on the upper surfaces of imbedded stones on the shore of the Gareloch, near Glasgow.

In 1852, my father brought into notice certain causeway-like *pavements* of boulders near Portobello, which remain, so far as I am aware, without any precise parallel. "There occurs deep in the clay, at two several points on our coast, what I have ventured to term *pavements*—for such is their appearance—composed of boulder stones laid as in a common pavement, with their smoother surfaces upwards, . . . grooved and rutted. As decidedly as the greenstone causeways of our streets bear evidence in their scratched and furrowed surfaces of the heavily-laden carts and waggons that have passed over them, are these pavements of the boulder-clay charged with evidence that great moving masses had also dragged their ponderous weight over them. But

[1] On the Midlothian and East Lothian Coalfields (Trans. Roy. Soc., Edinb., vol. xiv., 1838, p. 311).

the agent was evidently the same as that which grooved and polished the rocks beneath. . . . All of them I have yet observed have their direction and striation E.N.E.—the general direction in the district of the lines and grooves below; almost all of them decline slightly to the east, and, when relieved by the waves, resemble low flat moles stretching from the land into the sea. They indicate, I am inclined to hold, pauses in the formation of the boulder-clay deposit, during which its general surface was lowered and came to be thickly covered with the disengaged pebbles and boulders of the general mass, ranged in one place. And then the old agency recommenced its operations, and pressing the stones down into the mass, so as to imprint the pavement-like regularity on their surface, it grooved and striated them, as when acting at an earlier period on the rock below. These curious pavements may be regarded as conclusive in the proof they furnish that the boulder-clay was not, as some think, a simultaneously formed deposit—the produce of some great mud-wave from the sea—but of slow formation; and, further, that it presented surface after surface to the great grooving and polishing agent to which it seems to have owed its origin." [1] This agent he believed to have been icebergs.

These remarkable *boulder-pavements* (as my father terms them in an MS. reference) were pointed out by him to Robert Chambers, who also described them. [2] His description of the "narrow trains of blocks crossing the line of beach . . . not more than a foot above the general level" is virtually the same as that just quoted. "There are also," he adds, "some appearances of a hollow on the surfaces of these curious pavements, as Mr Miller calls them, as if some enormous wheel had run along the surface in that direction, and left on it a slight track;" and he concludes that here is "a surface of the boulder-clay deep down in the entire bed, which to all appearance has been precisely in the same circumstances as the fast rock-surface had previously been."

[1] Lecture on the Geological Features of Edinburgh. Reprinted in "Edinburgh and its Neighbourhood," pp. 38-40.

[2] Edinr. Phil. Jour., vol. liv. (1852-53).

In 1859, Professor O. N. Stoddard, of Miami University, apparently unaware (like the two observers last cited) of previous notices of similar phenomena, described in America a group of 141 boulders of various rocks uncovered in a railway cutting, and all striated in the direction of general glaciation. "The agency of running water," he says, "may be dismissed as utterly inadequate to explain the fact in question. Icebergs driven by waves and currents . . . afford a solution but little more plausible. Icebergs might plough up the bottom and scatter the fragments, but could not retain them in place. It seems necessary to admit that they were firmly frozen into the clay, and thus held in position while some overlying mass slowly ground off their exposed surfaces."[1]

Nothing has been done since 1859 that has, so far as I am aware, materially advanced the specific study of boulder-glaciation, except that here and there boulders have been observed and recorded as having been found striated in place. It does not appear that any of the groups have been laid quite in the *pavement* form. Mr Archibald Geikie, to whose review of the work of previous observers I have been indebted for references, describes two "striated pavements" (the adjective was added by Mr Geikie), one on the coast of Berwickshire and another on the shores of the Solway. Both of these appear to have consisted of a number of blocks "imbedded irregularly" in the boulder-clay. Mr Geikie pointed out that it was not as yet rendered quite certain that the striated blocks had lain under true till; that they had as yet been observed only near the coast; and that their striation was possibly a record of "the second great era of the drift," namely, that of floating ice.[2]

Since 1863, the instances of boulder-glaciation of which I have found specific mention have been recorded chiefly by Mr Milne Home and Mr John Henderson in connection with the Boulder Committee of the Royal Society of Edinburgh. Mr Milne Home, not forgetful of his early statement, that

[1] American Journ. of Science, vol. xxviii., p. 227 (1859).
[2] On the Glacial Drift of Scotland (Trans. Geol. Soc., Glasgow, vol. i., part 2, 1863, p. 68).

"it is an object of some importance to ascertain the direction of these ruts" even on single boulders, has given unwearied attention to certain minutiæ of boulder-glaciation, which few others have thought worthy of notice,—not only the direction of the striæ, but their arrangement on the stone, their limitation—or the reverse—to its upper sides, the direction of its longer axis and pointed end—to all the particulars, in short, to which attention had been called by the early school of observers, of which he is happily a survivor. These observations, however, remain scattered and undigested.

By writers on glacial subjects the "striated pavements" have been chiefly referred to as a remarkable phenomenon that at least must not be left out of sight. Each writer has been quite able to find a place for them in his own hypothesis. By some of the advocates of till-formation under half-floated glaciers they have been viewed as records of the intermittent pressure exerted on the accumulating materials.[1] By Mr Goodchild, who regards the till as one great charge of materials incorporated into the ice and left behind when it melted, like the litter of the St Petersburg streets after the spring thaw, they are considered as due to fits and starts of subsidence in the melting mass.[2] In Professor James Geikie's great work they are referred to among the non-marine beds intercalated with the Scottish till, of which, as all geologists know, he supports the sub-glacier origin;[3] and by Dr Croll they were viewed as a sort of supplementary evidence of long pauses and interglacial periods during its formation.[4] They have not been deemed of sufficient importance to merit notice in any text-book of geology.

Pavement-Boulders in the Till of the North of England.

My interest having been excited by my father's observations on boulder-pavements, I have for a number of years

[1] See at length Rev. R. B. Watson, F.R.S.E. (Trans. Roy. Soc., Edinb., vol. xxiii., p. 539), where this view is ably put forth.

[2] On Drift, Geo. Mag., 1874, p. 508.

[3] The Great Ice Age, 2d ed., p. 180.

[4] Climate and Time, p. 255.

been in the habit of giving to the glaciation of boulders something of the attention that it is usual to bestow upon the glaciation of rocks. My opportunities of observation have chiefly lain inland among stream sections and railway cuttings. I looked, therefore, not so much for boulder-pavements as for parts of pavements or *pavement-boulders*, such as imperfect sections might reveal, and began to note the glaciation of striated boulders in groups of five or ten, and then in twos and threes, and ultimately, as experience and data increased, singly.

The general conclusion to which these observations has led may be stated in a word. *The larger boulders in the till, quite irrespective of any arrangement in pavement form, are, in favourable situations glaciated, if at all, in the direction of ice-flow.*

Throughout the Border Counties of England, from the east coast at Newcastle and Tynemouth to Carlisle and Silloth upon the west, the evidence on the whole is uniformly trustworthy and to the point. It cannot be said, of course, that the larger boulders always bear striæ. It is scarcely less usual, however, to find the boulders striated in their place in the till when the till is good than to find the rock glaciated underneath.

It is not necessary to enter in detail upon the glaciation of the north of England. In general terms, Northumbrian glaciation may be roughly divided into—(1.) general glaciation, crossing the watershed from the west; (2.) valley glaciation, where the ice held with the valleys; and (3.) glaciation of the sea board, or along the coast from the north. When the rock-striæ and boulder-striæ marking this glaciation are set upon a chart side by side, and distinguished by means of different colours,[1] the two kinds of evidence are seen to agree in every detail. We are presented, in short, with two modes of arriving at the same facts, one of which might have been pursued if the country had been entirely drift-covered and the rock-striæ invisible. Both the boulder-striæ and the rock-striæ occur practically at all levels from the watershed to the coast. The highest-lying rock-striæ are

[1] As was done in a chart exhibited when this paper was read.

preserved at 1500 feet above the sea; the highest boulder-striæ occur at an elevation of 1400 feet. The lowest of each are at the coast line. There are tracts also which these two kinds of glaciation agree in registering as debatable ground,—where the ice passed now in one direction and now in another.

The north of England boulder-clay might with much truth be described as *one great striated pavement.*[1]

Glaciation, however, bore by no means equally upon all parts of the till. In certain hollows and notches of the surface—in many of the narrow preglacial stream-channels, for instance, which the ice crossed at right angles, the till found a secure lodgment, and could remain undisturbed. During the formation of a new reservoir for the Newcastle water-supply near Chollerford, the preglacial ravine of the Dry Burn, a feeder of the North Tyne, was excavated to a depth of 26 feet below the level of the modern stream. The stiff till that had occupied it was full of boulders, many of them having the characteristic smooth lobe-shape. These boulders were lying as if hustled-in in the passing, and their axes and striæ were disposed at random. This old ravine lay at right angles to the line of ice-movement.

For several reasons also it is more difficult to obtain good glacial evidence from boulders among the drift at high levels. The high level drift is often raw material; the sections of it, too, are increasingly obscure as we ascend. It is on the open and level country, where the till was well worked up, and the ice had a steady *purchase* or mechanical advantage over the surfaces upon which it moved, that boulder-glaciation is at its best.

Pavement-Boulders near Edinburgh.

This was the case in the low grounds near Edinburgh.

The accompanying small map represents sixteen sets of boulder-striæ in this neighbourhood. Three of them are Maclaren's original observations of the year 1828; five of them have been recorded by Mr Milne Home; two represent

[1] The term *pavement-boulder* which I find it convenient to employ, may be viewed in this wider sense.

my father's boulder-pavements; two have been observed by Mr John Henderson; and the remaining four are from my

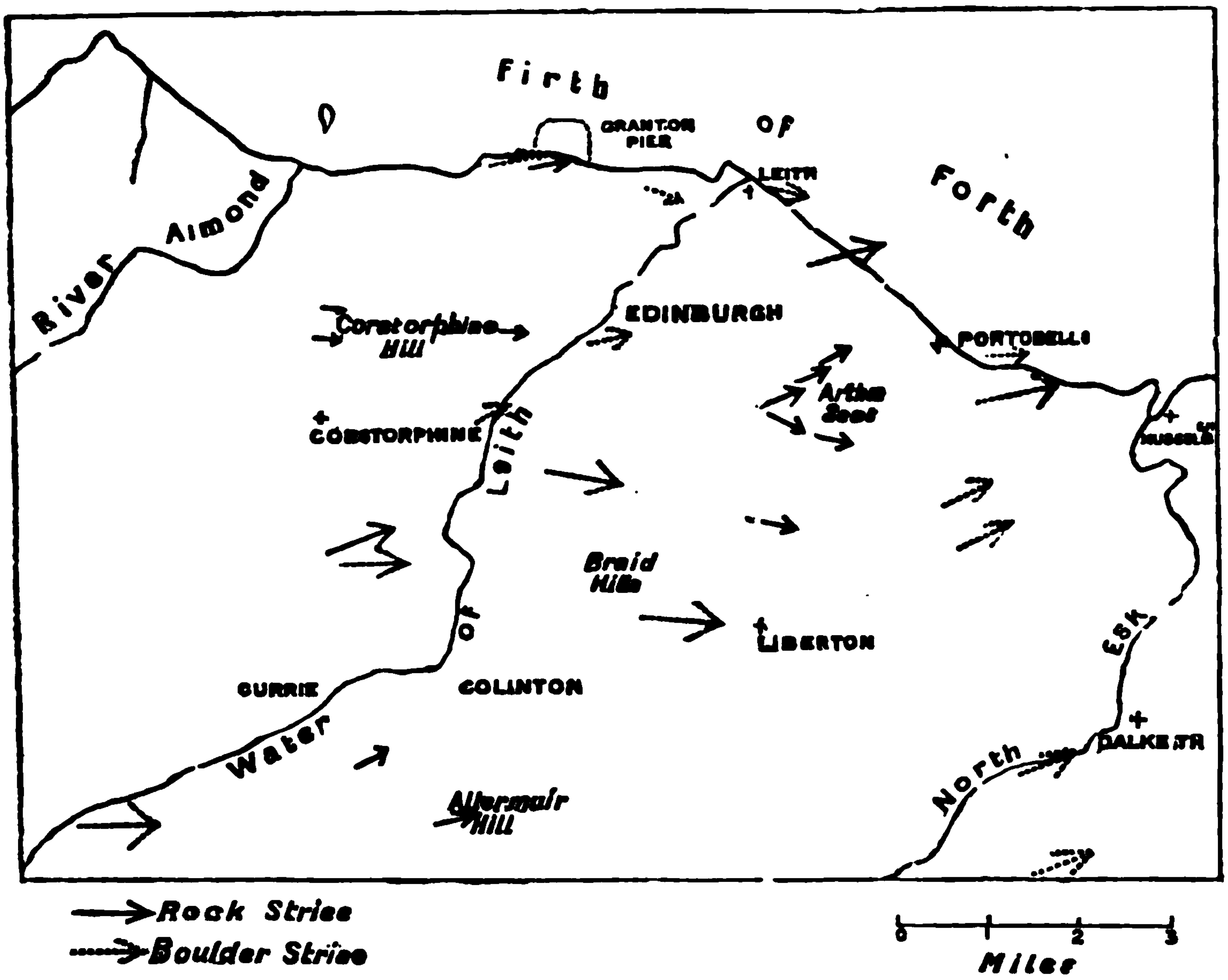

Fig. 1.

Glaciation of the neighbourhood of Edinburgh.

own note-book. I subjoin a list of the localities and authorities. A number of rock-striæ are denoted upon the map for comparison.

Boulder-Striæ near Edinburgh.

LOCALITY.	DIRECTION.	OBSERVER.
Railway cutting, Dalhousie Mains, . . . Beside railway viaduct, North Esk, . . . Railway cutting, Whitehill Mains, . . .	From 1 to 4 points, N. of E.	Maclaren, *Scotsman* 1828, and Geol. of Fife and the Lothians, p. 290 of 2d ed.
Waterworks, Alnwick Hill, near Liberton, . .	S.E. by E. (magnetic.)	Mr Black, supt., quoted, 4th Rept. Bldr. Commission, Roy. Soc., Edinb.
New docks, east end of Leith, ...	E. by S. (magnetic.)	Milne Home, 4th Rept. Bldr. Commission.

Locality.	Direction.	Observer.
Newhaven and Edinburgh railway,	E. ½ S. (magnetic.)	Milne Home, Trans. Roy. Soc., Edinb., vol. xiv., p. 311 (1838).
On the shore at Joppa,	E.—E.N.E. (magnetic.)	
Sand pit, Tynecastle,	E. 30 N (magnetic.)	Milne Home, Trans. Geol. Soc., Edinb., vol. ii., p. 346.
Fillyside, west of Portobello,	E. 10 N.	Hugh Miller, Edinburgh and its Neighbourhood, p. 35.
Near Magdalen Bridge, east of Portobello,	E.N.E.	
New Redhall Quarry,	Nearly E. and W.	John Henderson, Trans. Edinb. Geol. Soc., vol. ii., p. 392.
Whelpside, Water of Leith, above Currie,	E. and W.	Henderson, *ibid.*, vol. ii., p. 200.
Rothesay Place, Edinburgh,	E. 10-15 N. (5 boulders.)	H. Miller.
Granton pier, west of Custom House,	E. 5 N.—E. 15 N. (42 boulders.)	
Cutting, Suburban Railway, between Joppa and Niddrie,	E. 10 N. (4 boulders)	
Cutting, Suburban Railway, Colinton Road,	E.—E. 30 S. (7 boulders.)	

The unanimity of this evidence is obvious at a glance. It is especially interesting to observe the tendency in both kinds of striæ to divide around Arthur's Seat.

Little more need be said about the *evidence of direction* furnished by the glaciation of boulders lying *in situ* in the till.[1] There are some further details, however, which the glacialist will pardon me for entering upon. Some of these may be found of practical use in reading off the evidence in the field; some of the others have more or less of a general bearing.

Adjustment of the Boulders under Glaciation.

The adjustment of boulders under glaciation generally resembles that of small *roches moutonnées.* The side facing the ice is apt to be tilted slightly towards it, or to be ground down into a smooth slope with flowing outlines. The averted or sheltered side, again, retains more or less of its roughness.

[1] I must not omit to state that, on comparing notes on the subject with my friend and colleague, Mr B. N. Peach, I learned that he has for many years been in the habit of observing this evidence of direction and noting it upon his maps. The extent of Mr Peach's acquaintance with the geology of Scotland renders his testimony extremely valuable.

The figure (Fig. 2) represents part of a fine group of glaciated

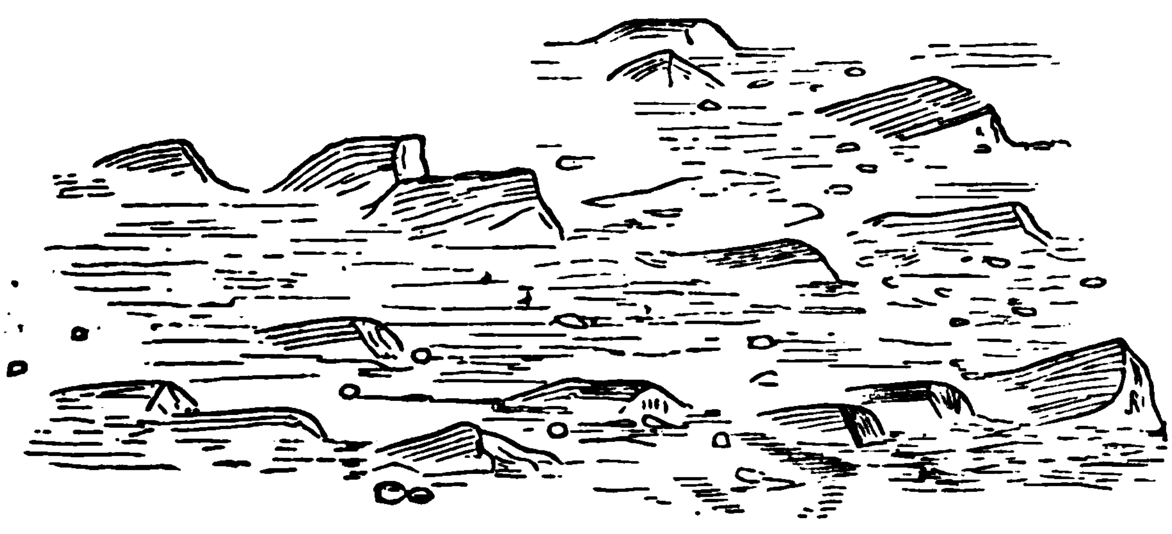

Fig. 2.

Pavement-boulders in Till on the fore-shore, Northumberland.

boulders sticking in clay upon the Northumbrian coast. A group somewhat similar, showing all the features of boulder-glaciation, can be seen at half tide upon the shore towards the west side of Granton Harbour. West of the Custom House I counted forty-two of them. The angle of the abraded slope varies, so far as I have observed, between 7 and 25 or 30 degrees. The longer axis of the stone is often directed in the line of glaciation, and the pointed end is frequently, but by no means always, (see Fig. 4,) towards the ice.

The Striæ.

In the largest size of boulder, the depth and firmness of the striæ differs in no degree from the groovings on solid rock. In the boulder represented in Fig. 3—a fine boulder of Corstorphine greenstone, about 6 feet long, recently uncovered beside Rothesay Terrace—the scoring was as deep and the polishing as fine as in the best rock glaciation, the largest scores being half-an-inch broad by one-eighth of an inch deep. The striæ in this case, which may be taken as typical, were confined to the top and upper flanks of the stone. As I saw it, it stood about 2½ feet high upon the cushion of

boulder-clay on which it still rested; the striæ became

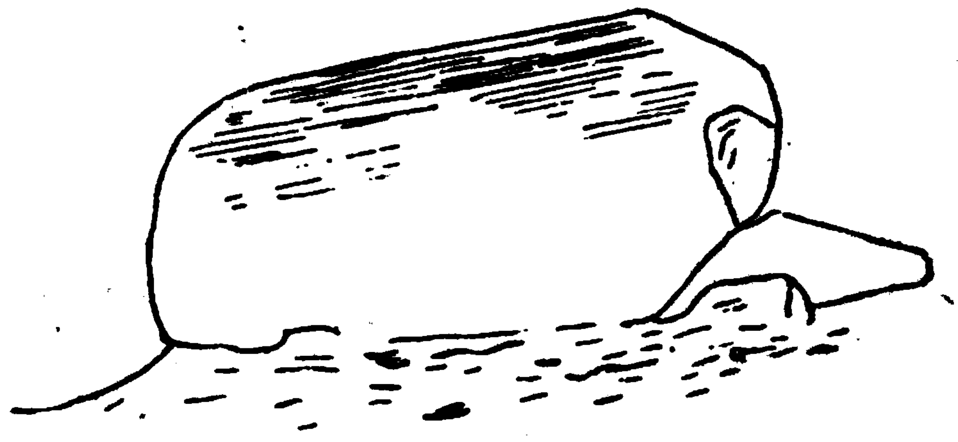

Fig. 3.

Greenstone Boulder, Rothesay Terrace, Edinburgh. Length, 6 feet.

lighter and fewer at about half-way down the sides, and died out at about a foot and a quarter from the bottom. The ice had moulded itself to the stone (Fig. 4). Along its middle

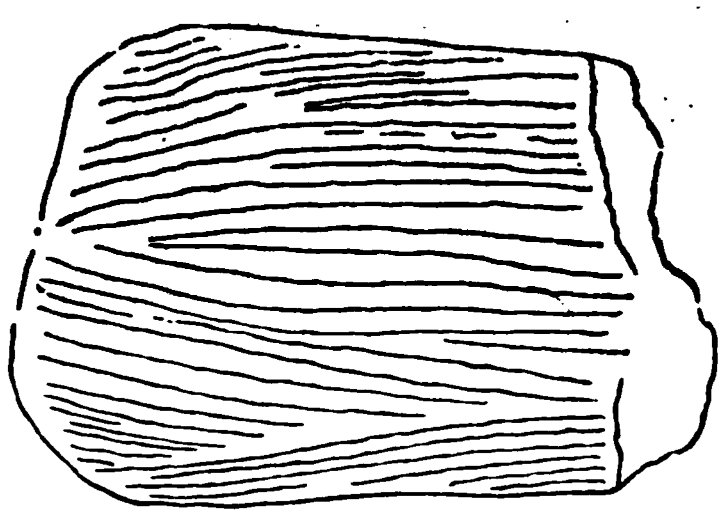

Fig. 4.

Sketch-plan, Rothesay Terrace Boulder.

line it was glaciated in the true direction, but as the striæ passed round its curving flanks, they diverged (as the arrows on the map diverge around Arthur's Seat), rounding the bulges and bending into the hollows—especially into one deep, bay-like curve on the side. The ice had behaved like water, which partly rides over the top and partly washes round the sides; and it was now as if the movements of the current had been rendered diagrammatic by means of incised lines. This boulder, like most others, had made something of an inclined slide of itself, by canting at 7 degrees towards the ice. At the averted end, the striæ and polishing ceased at once, and

the whole of the sheltered portion was rough-grained and sub-angular. Instances may occasionally be met with in which both the upper and the under side is striated. These, however, are few enough to be accidental. Whatever was the nature of the glaciating agent, it is certain that the boulders had undergone striation before they came to anchor in the clay, and faced the glacial tide; and they were liable to be torn from their moorings and turned over.

Depth at which they were imbedded.

The surface-glaciation of boulders is common to all parts of the till. In the long railway cutting of the Suburban Railway at Colinton, for instance, I observed pavement-boulders at 6, 10, 15, 20, 25, and 30 feet from the surface. The Granton group of boulders to which I have referred lie evidently at the very base of the till, where it rests upon shale, and is, in fact, a kind of shale-mash; and although, as was pointed out by Mr Arch. Geikie, the boulder-pavements on the shore further to the east are not now actually covered by till, there can be no doubt, from the presence of a small scar of till etched out by the waves here and there along the edge of the beach, that they, too, have lain—to use the words of Robert Chambers—"deep down in the entire bed," and have only been laid bare by the sea.

The Boulder-Pavements.

These boulder-pavements differ from other groups of striated boulders by their partial arrangement into strips of glaciated causeway.

During the thirty years that have elapsed since they were last described, the pavements at Fillyside have considerably altered. They have been better cleared out by the waves, and now, at half tide, they break the margin of the coast for about a quarter of a mile with a succession of low spits advancing obliquely seawards (Pl. VI.). There seems, thirty years ago, to have been just two. There are now at least six, and indistinct trains of imbedded boulders indicate at least as many more in an imperfect condition. The best of them are

linear strips like lanes; the most remarkable of them all resembles one of those strips or "slips" of causeway, inclined with the shore, on which it is usual to run the boats out to sea. Their slight eastward fall is, of course, towards the middle of the valley now occupied by the waters of the Forth, which probably sagged a little towards the centre, as many drift-filled valleys do. Besides this slight incline, two of the most lane-like and pavement-like of them have, throughout at least a part of their length, an even dip of two or three degrees a little south of east, or at right angles to their length. This dip I am unable to account for.[1]

The boulder-clay which underlies and originally enclosed these boulder-pavements is of a remarkably fine and well-kneaded kind, strongly clayey in its matrix, and handsomely varied in the stones that mottle its surface. In quality it contrasts very decidedly with the pavement. In some places

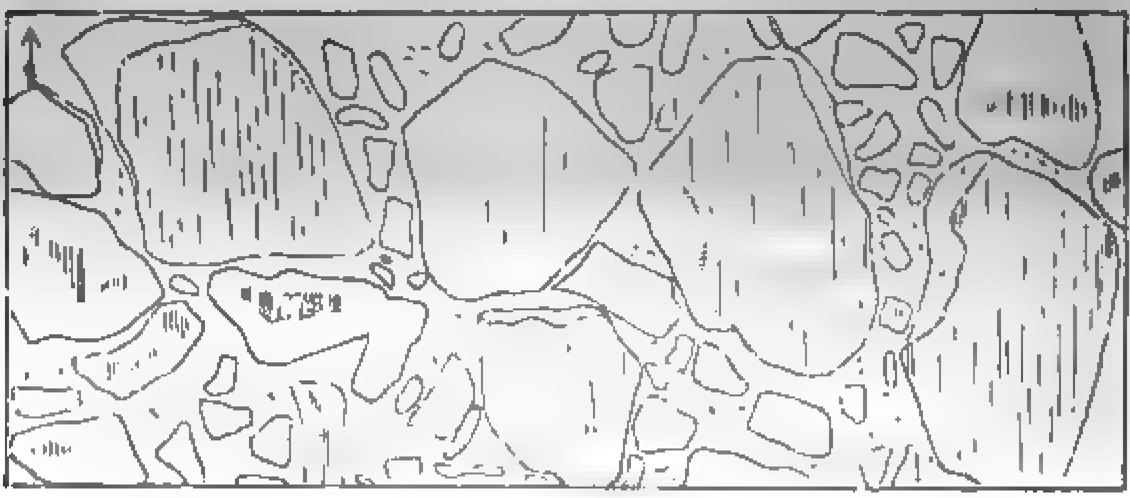

Fig. 5.

Sketch-plan of part of Boulder-pavement (scale 1 inch to 2 feet), Fillyside, near Edinburgh. The arrow denotes direction of ice-movement. *Note.*—The interspaces between the stones were occupied by the *débris* and litter of the sea-shore.

where the pavement is torn up, the till shows from under it nearly as distinct as the bed of concrete under the causeway

[1] Mr B. N. Peach suggests to me that this slope may be due to their position, towards one side, in the interior of a drum, or drift-ridge, now removed by breaker action. This, *a priori*, is extremely likely. But so far as I have observed, most of the single striated boulders on the coast have a similar tilt. Drums are bilateral. Why do these slope all one way?

of a street when the stones have been raised for a partial repair. The materials of the pavements are about as various as the scattered contents of the till. And having travelled different distances, with different uságe, some are more angular than others.

While the general slope of the pavements is seawards and southwards, such of the individual boulders as are best striated have more or less of the usual cant towards the ice. But they are modified by their pavement-grouping (Fig. 5). The smaller stones that are fitted in among the others have escaped striation altogether; others, rising a little higher, have been brushed atop; while others, again, have been planed off as flat and as square-edged as a laundry-maid's iron. The stones that have escaped striation altogether form perhaps the greater number of the whole. And it must by no means be overlooked that some of these boulder-groups upon the Fillyside shore are simply trains of boulders confusedly huddled together and unstriated: and that it is only in places that their arrangement is really so workmanlike as in Fig. 5. One large patch of stones on the westmost side, which, unlike the others, is broad enough to measure fully 70 yards across, and has only one straight edge, has been so lightly passed over that it was only after some search that I found any signs of surface-glaciation at all. On the whole, these boulder-pavements deserve to rank among the most singular glacial phenomena in the country.[1]

Conclusions.

The four general conclusions to which these observations—backed by others extending over some hundreds of square miles—lead, may be stated, to a considerable extent, in the words of Maclaren and Hugh Miller, of whose early observations they can profess to be only an extension.

[1] I have not observed the appearance of which Mr Robert Chambers speaks (my father makes no allusion to it), of a hollow on the pavements, as if some great wheel had run eastwards and left a slight track. One cannot but remark, however, upon the singular prevalence of straight lines among these boulder groups, that gives the whole series some resemblance, from a distance, to the hollows and crests of a roadway deeply marked with ruts.

1. The larger boulders throughout the till, as I have already stated, are glaciated generally in the direction of ice-flow.

2. To this glaciation they have been subjected "in the position they now occupy."

3. The till was, as a formation, slowly built up, and "presented surface after surface to the great grooving and polishing agent."

4. The glaciating agent was the same that had already acted more or less upon the rocks below.

The applications of these general facts may be summarised in a few words. We have seen that the glaciated boulder-surfaces correctly register the direction of ice-movements. They ought, therefore (1), to serve as guides to the glaciation of drift-covered districts, and (2) to register some of the changes of ice-movement during the progress of the formation, and throw better light upon the intercrossing of erratics. The presence of pavement-boulders may also ultimately prove (3) a distinguishing mark of those formations that are to be correlated with the true till. And if it be, as it certainly seems, impossible for icebergs to glaciate, in fixed directions and uniformly upon one cheek, so many blocks lying loose

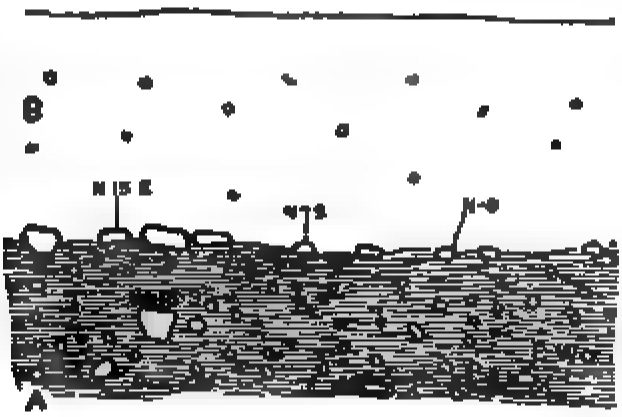

Fig. 6.

Two Boulder-clays, with derivation marked by the striation of boulders, Northumberland. A, Till, 8 to 10 feet ; B Till, 20 feet.

at the sea-bottom, they may add (4) another and very strong proof of its origin as a ground-moraine.

(1.) Of what practical value boulder-glaciation will prove in drift-covered districts generally, especially among the imperfectly wrought-up drifts of southern England, remains to be seen. Dr Croll has proposed to determine the movements of the ice in these regions from the direction assumed by contortions in the drift.[1] This method by means of pavement-boulders seems more workable, and has at least the advantage of having been tested.

(2.) The extent to which the successive surfaces of the boulder-clay have registered the changes in ice-flow during its formation can best be illustrated by a concrete example. Fig. 6 represents two boulder-clays differentiated by (among other things) the glaciation of the boulders they contain in directions at right angles to one another. The cross-hatching on rock-surfaces, which has hitherto been brought in as evidence, doubtless register one or two of the earlier changes of ice-movement. But, except where it can be supposed that a cover of boulder-clay has been laid down and stripped off again in the interval, we have been really left to general evidence as to the variations that supervened during the stages of the deposit. Questions respecting the intercrossing of erratics also remain as yet questions of general evidence.

If the till were an evenly deposited formation, it might be expected that *all* the changes of the ice-currents should be registered in its successive layers. But the till, of course, is an irregular formation. Every renewal of impetus or change of direction probably caused the ice to attack its own deposits at changed angles or with renewed force. No one can study the till minutely without seeing that erosion and reconstruction were in progress simultaneously.

In the neighbourhood of Edinburgh the direction of glaciation seems to have remained pretty constant throughout. The same may also be said, though to a less extent, and with remarkable exceptions, of the county of Northumberland. But in the west of the county—in that large tract of low ground that borders the Solway—it appears to have been otherwise. It is probable that the Solway Firth may be viewed as a

[1] Climate and Time, p. 462.

large trough, in which a *potpourri* of boulder-clay was stirred together, ready to spread out eastwards and southwards.[1]

(3.) The value of the surface-glaciation of boulders *in situ* as a distinguishing mark of the true till, or of the deposits that are to be correllated with it, chiefly remains for the future to show. To illustrate it fully is beyond my power; and even to illustrate it partially would lead me further into local details than is at present desirable. I may say in a word, however, that it has already gone far to resolve some questions of correlation that were long, to me at least, extremely doubtful.

(4.) It is interesting to find that boulder-glaciation *in situ* by glaciers is not by any means a mere hypothesis. In front of the glacier of the Argentiere, says Professor Bonney, "there is an extensive area now covered with boulders, which within the last few years has been abandoned by the ice. . . . Many of the smaller blocks on this area, now almost concealed by rubbish scattered from the retreating glacier, are smoothed and striated as if by passing ice. . . . Here and there are large, prominent, protogine blocks, several of which distinctly show, by the striations on their sides and surface, that the glacier has flowed over them. Three lie near together; their tops are polished and striated and littered over with moraine; they do not form part of a lateral or terminal moraine, but are in an open plain. Striation, *stoss* and *lee seite*—everything is just as it should be had the glacier flowed over them, and each has a tail of moraine. The largest was 12 by 7 by 5 yards."[2]

Mr Bonney continues—and his remarks are an excellent comment on the details of boulder-glaciation with which I have troubled the reader,—"The above observations tend to show that ice is a far more plastic substance than some physicists would allow. . . . It occasionally flows after the manner of water, over and round an obstacle, instead of sweeping it away, and appears to pass over *débris* as a river does over a gravelly bed."

[1] The part, however, which ice-movements took in mixing up this boulder-clay preparation is not yet quite certain.

[2] Notes on Glaciers, Geol. Mag., 1876, p. 198.

II.—Fluxion-Structures.

Longitudinal Striation of Stones in the Till.

It is one of the most characteristic features of the boulder-clay that all its almond-shaped or spindle-shaped boulders are striated longitudinally.

"If the force of water could have scratched and furrowed them," says a writer whom I need have no hesitation in quoting, "it would not have scratched and furrowed them longitudinally, but across. Stones when carried down a stream, or propelled upwards on a beach by the waves, present always their broader and larger surfaces to the moving force. . . . They are not *launched* forward, as a sailor would say, *end-on*, but *tumbled* forward *broadside*. They come rolling down a river in flood, or upwards on the shore in a time of tempest, as a hogshead rolls down a declivity. In the boulder-clay, on the contrary, most of the pebbles that bear marks of their transport at all were not *rolled* but *slidden* forward in the line of their longer axes. They were *launched* as ships are launched in the line of least resistance, or as an arrow or javelin is sent on its course through the air." [1]

I am acquainted with the writings of only one of that famous Scottish school of geologists to whom it fell first to study and debate the boulder-clay, who, mainly through the perversity of his views on the subject, hit upon what I conceive to be to a large extent the *rationale* of this fact. "Although the clay," says Fleming, "was sufficiently dense to retain the boulders floating confusedly in its substance, *it was fluid enough to admit of motion.*" [2]

Striation by means of the Matrix.

It appears certain that many of the smaller boulders were slidden along and glaciated *in their place in the clay.* The

[1] Hugh Miller, On Peculiar Scratched Pebbles, etc., in the Boulder-Clay (Brit. Ass. Report, 1850, p. 94).

[2] Lithology of Edinburgh, p. 61. Fleming held to the last by the "mud-wave" theory. He does not appear, however, to have observed the fluxion-structures.

large boulders, as we have sufficiently seen, bear striæ in no wise differing from those of glaciated rock. Pieces of coal or shale the size and shape of a taper finger nail, on the other hand, bear lines as minute and magnifiable as the delicate lines *on* the finger nail. These little boulders have not apparently been brought into rude and direct contact with the rock or with each other. Their striæ are just such as would be caused if, carried along in a wrapping of clay, they had been scratched by the particles of the matrix, and dealt with gently and with approximate equalisation of pressure (see Fig. 8).

Structure of the Matrix.—Microscopic Boulders.

It need not be said that this is not restricted to boulders the size of the finger nail. It is possible to pick out from well-wrought boulder-clay a scale of lessening sizes leading down to a point at which the glaciated character of the particles is lost to the naked eye. "If the clay be washed and sifted," says Professor James Geikie, "it will be found to be composed of grains of all shapes, sizes, and weights, down to the finest and most impalpable flour."[1] The grains, in fact, exhibit all the varieties of form that are found among larger boulders. Many of them are angular; others are in various degrees of roundedness; others, again, are of characteristic oval and lobate boulder-shapes—some with the indistinct longitudinal etching of surface that covers many stones in the boulder-clay either too rough to take striæ or not long enough under the process, and some striated distinctly.[2] Many little boulders can be detected, measuring about the 100th part of an inch in length, and bearing striæ about the $\frac{1}{2000}$th of an inch in diameter.

Fig. 7 represents a few of the best striated and most characteristically shaped boulders obtained by washing the well-kneaded boulder-clay on the Fillyside shore free from the

[1] Intercrossing of Erratics, Scottish Naturalist, vol. vi., p. 249.

[2] I am indebted to Professor James Geikie for first informing me that he had detected glacial striæ on felspar grains, running transverse to the planes of mineral striation; and on the first occasion on which I looked out for it myself I had the help of Mr B. N. Peach.

more floury material. The residue chiefly consisted of quartz-grains, grains of shale and coal, and some bits of iron pyrites. The specimens figured in the woodcut are all

Fig. 7.

Microscopic Boulders.

of quartz, except the smallest, which consisted of a green serpentinous-looking mineral, extremely lithographic, and beautifully turned and striated. They have the lobate form of the glaciated boulder, with one end more pointed and the other squarer or blunter. Even *they* seem in some cases to have been launched forward end-on, as if in the path of least resistance, and to have the striæ passing straight along the back, and bulging slightly out around the sides. And in some instances I thought I detected firmer striæ upon the point of the little boulder than upon its broader end.

Granule-Glaciation—How Accomplished.

All this seems to point to glaciation within the matrix. "The blacksmith, let him use what strength of arm he may, cannot bring his file to bear on a minute pin or nail until he has first locked it fast in his vice." And why else were the almond-sized boulders glaciated not in contact with each other or with the rock but by the granules of the matrix?

Fluxion-Structure in Boulder-Clay.

At the corners of streams in boulder-clay districts it is usual to find slipping scars of boulder-clay that in wet weather are turned into streams of slow-running paste. When these are examined—say in summer, when hard baked—it is found that a rude structure has been developed by the movement. The streaming of the particles has steered the stones round until pressure is equal on both sides. Their

axes have thus been dragged into the line of flow. In the case of some of the stones *over* which the pasty current had passed, I even detected faint, fresh scratches running among the older glacial ones, and parallel to the axis of the stone. Now, this is a structure very extensively to be found in the boulder-clay *in situ.*

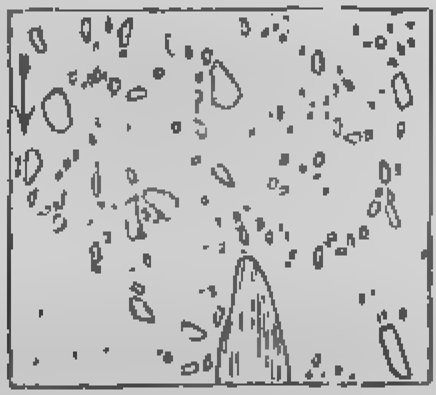

Fig. 8.

Fluxion-Structure in Till (natural size), Fore-shore, Fillyside, near Edinburgh. The arrow denotes the direction of ice-movement.

Fig. 8 represents a square inch of the horizontal plane of boulder-clay on the foreshore at Fillyside. The clay and the stones appear to have been in motion. The axes of the stones have been turned by a common force in a general direction—that of the glaciation on the boulder-pavements adjoining—and from boulders a quarter of an inch in length one can trace a scale of descending sizes down to minute boulders the size of a very small portion of a fine pin's point. From what we have just seen of the microscopic structure of the matrix, there can be little doubt that if a translucent section could be obtained for the microscope the grains would display a structure similar to the crypto-crystalline fluxion-structure of igneous rocks.[1]

[1] Unfortunately the attempts to render this boulder-clay fit for slicing by stiffening with Canada balsam have hitherto failed of success. The balsam refused to penetrate the clay. In an excellent hand specimen which I cut out (and from part of which Fig. 8 is taken), the results of fluxion-structure are indicated with such nicety that Mr Peach determined the *direction* of ice-movement without hesitation. The narrowed ends of the boulders in that specimen chiefly pointed one way, like index fingers. But this is by no means general.

Around many of the larger boulders the current is seen to have divided (Fig. 9). The longer axes of the little boulders begin to diverge at the point of the big one, (with perhaps

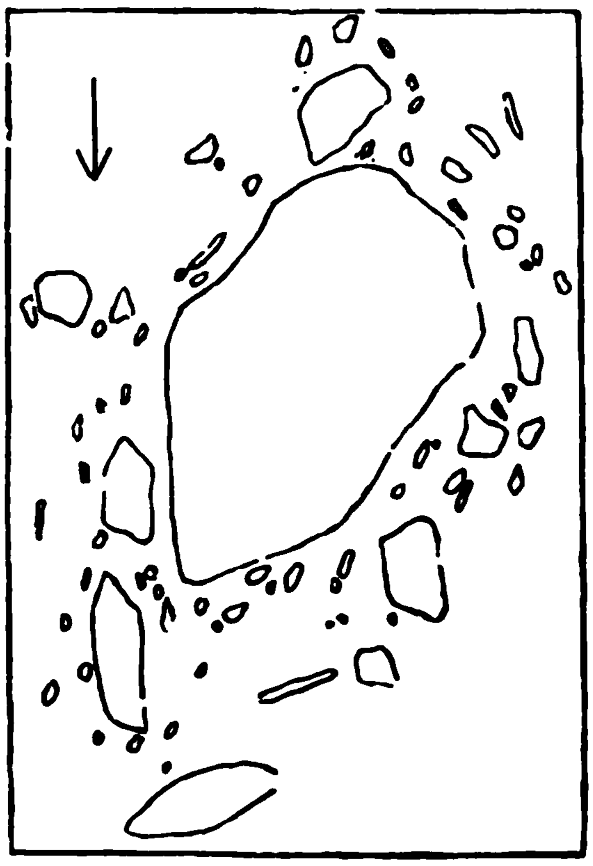

Fig. 9.

Sketch-plan Fluxion-structure around a boulder (⅛ natural size), Fore-shore, Fillyside, near Edinburgh. The arrow denotes direction of ice-movement.

a boulder or two stranded against its point,) and course alongside it, keeping a general parallelism with the sides as they go. A few inches on either hand the general course of the current remained undisturbed. In all cases which I have examined, the gritty matrix must have moved past the stone as the tide moves past a skiff at anchor. Fig. 10 is a sketch rudely representing a very delicate and beautiful fluxion-pattern around a boulder in till, on the South Tyne near Haltwhistle, more distinct in its fine hair-lining than I would have expected to find in a gritty boulder-clay. The boulder, which was somewhat pear-shaped, 5 inches deep, and of limestone, was striated from top to bottom on the whole side that met the ice. The blunt end was smooth, but I observed no striæ; and it resembled the rounded joint of a bone, compared with its lined and glancing shaft. Several converging lines showed that the current had closed in after passing.

Now, all this is unmistakable fluxion-structure. "In what is termed fluxion-structure," says Mr Arch. Geikie, "crystals or crystallites are arranged in current-like lines, with their

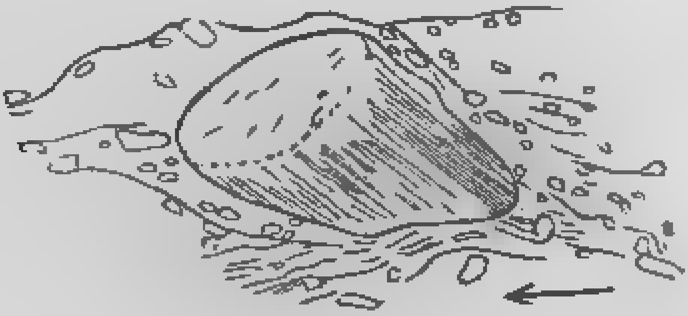

Fig. 10.

Fluxion-structure around a boulder in vertical section (scale ½ natural size), South Tyne, near Haltwhistle.

long axes in the direction of these lines. Where a large older crystal occurs, a train of minuter individuals is found to sweep round it, and to reunite on the further side. . . . So thoroughly is this motion characteristic of a somewhat viscid fluid, that there cannot be any doubt that such was the condition of these masses before their consolidation."[1]

There can be as little doubt that the structures I have described indicate the dragging along of a surface layer of the boulder-clay, accompanied with a shearing movement of particle upon particle, producing intimate glaciation within the mass.

The Movement Differential.—Thickness of Fluxion-Layer.

It is not probable that this shearing layer of boulder-clay was thick. A granular movement of the matrix of a kind sufficient to produce striation of quartz grains must have been accompanied with vast friction. Any force, however great, may well have been reduced to nothing when distributed among such numbers of inert particles—as the force of a cannon ball is spent when it buries itself in sand.

The fractured boulder in Fig. 11 seems to indicate in an interesting manner that the movement was differential in character, and, like the movement in a glacier, decreased

[1] Text Book of Geology, 1st ed., p. 104.

downwards. The main body of the larger boulder represented has evidently come into a state of rest, along with the lower part of the deposit. The striæ on its upper part indi-

Fig. 11.

Section indicating differential movement in gravelly Till, New Dock, Silloth. Scale about 1 inch to 1½ feet. B.Cl. gravelly Till, Sd. Sand.

cate that moving stones and clay had continued to pass over it for some time afterwards, while the till was slowly gathering around. The fractured and detached *cap* of the boulder was carried on (in the direction of ice-movement), owing to this continued movement of the later deposit; and after *it* had, in turn, ceased to move, the gravelly till had continued to pass on, the stones sliding up its front slope with axes adjusted parallel to it, and then turning over as if plunging down with the sluggish current on the further side. The little sand-bed above is one of the ordinary insertions of aqueous deposit in the till, and may indicate a little contemporaneous erosion by means of water, or the formation by some means of a small unoccupied basin or pouch on the surface of the clay.

To satisfy inquiry as to the thickness of the fluxion layer is a matter of some difficulty. But an answer may perhaps be suggested by the relation of the till to its larger boulders that were glaciated *in situ.* The large Edinburgh boulder, with its fine glaciation atop, represented in Fig. 3, was 2½ feet high, and had been glaciated only to a depth of about 15 inches. It appears, therefore, that while its upper surface was in direct contact with the glaciating agent, its lower

part, 18 inches imbedded, was surrounded by motionless till. And if this reasoning holds good in general, the thickness of the fluxion-layer cannot have exceeded a few inches. This line of inference, however, is a very insecure one, depending primarily upon an unascertained fact, viz., the direct proximity of the glaciating agent to the upper surface of the boulder. I have frequently seen little bits of shale, not more than $\frac{1}{10}$th of an inch deep, of which the upper surface was well rubbed, while the lower surface was almost untouched. *The sole of the boulders,* as Robert Chambers used to term their flatter side, seems generally, in fact, to have travelled uppermost. And it may be remarked that the fact noticed by Dr James Geikie, that there is "some curious connection" between the size of the stone and the coarseness of its striæ, seems to imply that every boulder was liable to be striated by just such materials as were more mobile than itself. But, quitting these obscurities, it seems at least quite certain that in sections such as that of Fig. 6, where different boulder-clays overlap, the movement extended no considerable distance downward.

I am aware that it is usual to suppose the pressure and motion of the ice to have been transmitted through *thick masses* of drift and down to the surface of the rock below, so that the till, like a rolling snowball, licked up its additions from beneath. Mr Tiddiman, for instance, takes this view of the drift of the Lancashire uplands, and represents the local drift as actually forming beneath an older and further-derived drift superposed. It appears more probable, however, that the local drift was manufactured whilst the foreign import was still on the way. This, at least, is the only intelligible explanation of either the structure or the order of the drifts of which I have any practical knowledge. It seems too much to assume that "the whole mass of *débris*" was in motion at once.

Distribution of the Fluxion-Structures.

Fluxion-structure, so far as I am aware, is generally characteristic of well-kneaded till upon tolerably open ground. My first attempts to discover it; about seven years ago, met

with but doubtful success. They were made at sections, which, though the best I then had access to, lay too much under the shelter of higher ground. In uplying situations also, where the drift is apt to be a hash of angular fragments in a coarse and scanty matrix, fluxion-structure is generally difficult to detect; and the same may be said of that top-dressing of raw materials which forms the capping of many good sections. Nor can it be invariably expected even in the

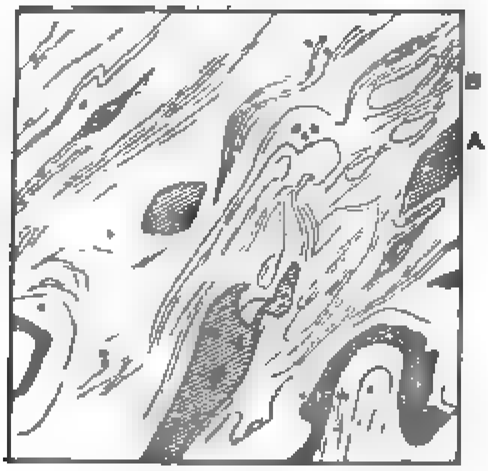

Fig. 12.

Contorted Fluxion-structure, Northumberland, representing one square yard horizontal surface. A, Dark Till finely stony; B, Red Till, stones absent.

most favourable situations. Fig. 12 represents a contorted fluxion-structure of differently coloured clays kneaded together, which better than any words will explain the reason. It is obvious that a structure of this kind could only be displayed where the section is unusually clean and the texture unusually fine, and where there has been a warp and woof of distinct boulder-clays to work together. In general, this rolling and kneading would produce nothing but confusion. No student of the till needs to be reminded of the frequency of obscure symptoms of contortion within its mass.

Orientation by means of Fluxion-Structure.

I have only recently made any strict test of the extent to which the direction of ice-movement can be determined from the symptoms of fluxion-structure alone.

Choosing a tract on the watershed of England, lying southward from Spadeadam Waste, in the parish of Lanercost, Cumberland, a monotonous rolling slope covered with long, low drums, from the trend of which it might be inferred that the drift had been well drawn out in the direction of ice-flow, I ascended the streams, and at favourable points (I preferred points at which I had as nearly as possible lost my bearings among their windings) set myself to orientate from its structure. The following list of the trials made will indicate the extent of my success. The rock striations of the neighbourhood vary between E. 10 N. and E. 20 S.[1]

Trial No.	Direction Indicated.
1.	E. 20 N.
2.	N. and S.
3.	Indeterminate
4.	E. and W.
5.	E. 20 N.
6.	E. 10 N.
7.	Indeterminate.
8.	E. 20 N.
9.	E. 5 S.
10.	Indeterminate.
11.	E. 5 N.
12.	E. 20 S.
13.	E. 20 N.
14.	E. 5 S.
[2] 15.	E. and W.
16.	Indeterminate.
17.	Contorted.
18.	E. 5 N.
19.	E. 10 S.
20.	E. and W.

In the cases marked *indeterminate* I failed to "agree upon a verdict." But in general, exercising proper care, and taking one stone with another, and having regard, especially, to such *groups* of well-glaciated spindle-shaped stones as agree in their trend, and serve as the *index-boulders* of the sections, the verdict may be given with considerable confi-

[1] It is quite worth noting that while the rock striations are generally east or a little south of it, the trend of the drums is almost invariably north of east, though generally less than twenty degrees.

[2] From this point downwards the observations were made on lower ground further west.

dence. Many stones have veered to this side or to that, or tilted into the various positions that give the appearance of structurelessness to the whole; but these variations often cancel one another in favour of the mid-line along which the best index-boulders lay their axes.

To account, however, for all the variations apparent in any one section, it would be necessary first to see all round it. In the shore-sections near Portobello, there seemed in places to be interferences with the normal direction of fluxion-structure which there was nothing apparent to account for. Behind some large boulders also I seemed to detect considerable confusion. In the tails of drift, whether behind boulders or bosses, confusion might be expected. And in such stiff and slow-moving materials it is difficult to say how long it need take the stones to regain their normal *drift*.[1]

III.—Conclusion.

It would probably be vain to take any one structure in the till and expect it to be universally characteristic. Fluxion-structure, as we have seen, is not universally characteristic, for there are materials too coarse or too raw to assume it. Neither can the surface-glaciation of boulders in their place in the clay be declared to be universally characteristic. There are boulder-clays whose boulders were too small to withstand it.

[1] I have seen no evidence of any regulated *eddy*. In some cases I have noticed that the force brought to bear upon the front of a boulder had evidently compressed the till behind it, imparting a kind of concentricity to the axes of the little boulders.

There is a peculiarity of structure in the Fillyside till to which I may refer. It was observed by Mr Peach in the hand specimens I showed him, that the small boulders were mostly laid up on edge, as if running on their keels. Now, it might be expected that where there was much lateral pressure the clay might assume some of the characteristics of the cleavage of slaty rocks or of laterally compressed ice. And one of the symptoms of the lateral pressure might be that the little flat boulders would erect themselves on edge. The difficulty is that, so far as can be seen, there is no compressing cause on the gentle side-slope of an open valley. There is nothing to produce even cleavage-structure in ice. This edge-position of the boulders is not the usual one. I fail to find it in valleys, where it might be much more expected, if this explanation were the correct one.

But it may at least be said that these two varieties of structure are in a singular degree complementary of one another. Both of them, each in its own way, tells the story of the building-up of the boulder-clay slowly and under pressure.

It seems certain that the pressure must have been that of a vast and wide-spreading mass—a mass closely investing and slow-moving and heavily dragging. I had meant to enter in some detail into the theories of glaciation as bearing on these structures; but it seems almost unnecessary. I have tried to conceive of thousands of boulders dotted through the ooze of a silty sea-bottom over hundreds of square miles, each awaiting the chance scrape of a passing berg, and eight out of every ten (in many open situations), though objects so small and so loose, fated to receive a heavy and persistent striation on one cheek; but in the case of boulders 6 and 9 inches long it seems physically impossible. I have also tried to imagine long hollows trailed out by dragging icebergs into which the semi-fluid clay of the sea-bottom should *run*, somewhat as the wind runs along with a train, but it gives to the prevalence of fluxion-structure an exceedingly lame and partial explanation. Nor is loose coast ice, which glaciates horizontally in zones, nor the frame of the ice-foot, which must glaciate radially from the centre of every island and promontory, at all a more adequate explanation.

But to the theory, if it must still be termed a mere theory, of confluent glaciers, one turns as to a really competent agent. For the fluxion-structure it accounts at once. It needs only to be assumed that the dragging ice communicated something of its own motion and structure to the clay over which it passed. We know, if only from Tresca's experiments, that ice assumes a fluxion-structure under a pressure that induces movement. From his other experiments we are also made aware that even solids as dense as lead and iron are made to "undergo an internal motion of their parts" when they are "placed between the jaws of a powerful compressing machine."[1] That under the jaws of a much more powerful compressing machine boulder-clays should undergo this "motion of parts"

[1] A. Geikie, Text Book of Geology, p 313.

and develop fluxion-structure, was quite to be expected. It need scarcely be remarked that the other structure to which I have devoted this paper is, generally speaking, a result of the same process. The fluxion-structure is the result of movement; the pavement-boulders are those elements in the materials that, making of themselves inclined slides, could best *resist* the movement, and were striated atop in resisting.

It does not follow, however, that wherever we find an orientation of boulders in the till there was fluidal motion in the layer in which they lie. If the ice had a fluxion-structure of its own, such boulders as were incorporated within its mass would arrange their axes conformably; and when they lagged and came to rest and were imbedded, they might retain in many cases the arrangement that marked them when in motion. There seems to be some proof that this was often the case. In many boulder-clays there occurs a certain structure of irregular horizontal planes having some tendency —sometimes a very marked one—to coincide with the surfaces of pavement-boulders, and dodging unevenly among the others. Some of these wavy planes may be due to pressure —an incipient sort of cleavage developed under the weight of the ice. Sometimes, however, the planes may be seen to open out a little and to include siftings of clay or washes of sand and stones of a different texture to the till; and I believe that they probably are more often due to *packing* than to pressure. They somewhat resemble these uneven planes that in a packing-case mark the order in which the bunches of straw were bundled in and packed down and smoothed over, and the glaciated boulders and the slight surface washes mark the intervals. Mr Mackintosh, indeed, refers them to aqueous lamination entirely; but this view does not stand the searching examination to which it has been subjected by Professor James Geikie.[1] Professor Geikie himself regards them as pressure-planes. I am convinced, however, that in many cases they indicate a rude stratification of that clumsy kind that marks periodical accumulations in which the sifting agency of water has not been concerned, such as the refuse

[1] The Intercrossing of Erratics in Glacial Deposits (Scottish Naturalist, vol. vi., pp. 193, 241).

of blast furnaces and of shot rubbish heaps in general,—that they are, in short, irregular planes marking successive accretions of till. If this be so, it follows that, where numbers of these planes intersect the planes of forward movement in the boulders, the fluxion-structure is the *pseudo*-fluxion-structure I have referred to.[1]

Of the boulder-pavements on the Portobello shore, I have no very novel explanation to offer. It seems likely that, as my father suggested, they must mark some kind of contemporaneous erosion. The variety of their materials seems to prove that they were first incorporated with the till in the ordinary course of its formation, and assumed their peculiar grouping subsequently. But whether the erosion was glacial or aqueous it is difficult to say. I have seen straight ravines on boulder-clay slopes lined with washed-out blocks that, if passed over by a gigantic roller, would flatten out into trains not unlike these pavements; and, of course, in the case of a glacier, the roller would be one that might both flatten and erode. Nor need it be wondered at that the trains should flatten out in places with pavement-like regularity. The stones in any ordinary stream, if they have but flattened

[1] There is some reason to think that the structure in Fig. 10 is of this kind. The shapes of the stones in the till, moreover, seem to prove that some of them moved freely and independently. Boulders having a curved sole appear to have rocked as they went; boulders with a twist or slue in them hirpled along more or less zig-zag. When a deposit like boulder-clay is in question, however, it appears unsafe to draw sweeping deductions from single facts. I find that Mr John Henderson, our well-known Edinburgh geologist, declares, respecting a large thin slab of sandstone, 7 or 8 feet in its diameters, and only about a foot thick, which he found carried from its original bed half-a-mile on to felstone rocks near Bonally, that it must have been floated by ice; "for," says Mr Henderson, "if it had been picked up at the bottom of a glacier, and rubbed up one hill and down another, to the spot where it is now lying, such a large thin slab must have been broken all to pieces" (Trans. Geol. Soc., Edinb., vol. ii., p. 365). But are there no alternatives? It may have fallen *upon* the ice during a thawing; or it may have worked up into the ice and scarcely touched the rock at all; or it may have been detached from a projecting out-crop ridge, and so got inserted at once into the body of the ice; or it may have lain in drift a few feet from its parent bed, and in some slight change of ice-movement been carried away with drift still round it. It is quite certain at least that a few such facts or riddles will not upset the glacier theory.

sides, are arranged in a sort of imbricated pavement already. But there are one or two details of their structure that do not quite so well consort with this explanation.

There is another kind of linear arrangement with which I may suggest that the pavement-boulders have occasionally something to do. I refer to certain of the drums or drumlins. It has often puzzled me how, in an open country, where there are no bosses of rock, these long drift ridges can have come into existence. It is easy to conceive, however, of the lodgment of groups of boulders, having the familiar arrangement suited to resist further transport, which should afford shelter to tails of drift, as the chance grains under a house-painter's brush give shelter to little tails of paint; and that with this beginning a sort of composite *roches moutonnées* should be gradually built up, each more or less *faced* with pavement-boulders. The suggestion may at least be made.

XVII. *The Breadalbane Mines.* By James S. Grant Wilson, Esq., H.M. Geological Survey of Scotland, and H. Moubray Cadell, Esq., B.Sc., H.M. Geological Survey of Scotland.[1] [Plates VII. and VIII.]

(Read 19th March 1884.)

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Introduction.

We propose to give in the following pages a short account of the metal mines in the district of Breadalbane, in Perth-

[1] Communicated by permission of the Director-General of the Geological Survey.

shire. They are all situated in the wild and beautiful part of the Highlands drained by the Tay and its tributaries, and in describing them we shall begin with the highest—Tyndrum—and take the others in order as we descend the valley. A list of the various metallic and non-metallic minerals from each locality will be given along with some account of the history of the mines, while special reference will be made to the geological structure of the ground. A general comparison will also be drawn between the features of these and other ore deposits, and notes will be made on the facts bearing on their formation.

Short notices of the mines at Tyndrum are given in the Old and New Statistical Accounts of Scotland, but the first paper of any value was written by F. Odernheimer, and is published in Vol. VII. of the Highland Society's *Transactions* (1841) under the title "The Mines and Minerals of the Breadalbane Highlands." The author gives a description of the mines at Tyndrum, Tomnadashan, and Corrie Bui, with their ores and accessory minerals, and indicates the position of several small untried veins around Taymouth.

Gustavus Thost, who was the last manager, gives a more extensive account of the mines and minerals of Breadalbane in a paper communicated in 1860 to the Geological Society of London.[1] His description of the geological structure of the various localities is, however, rather vague, and we hope now to throw a little new light on the subject, as we have worked out the geology of the region in some detail. To add perspicuity to the text we have constructed geological maps and horizontal sections of the two principal areas under notice. Our best thanks are due to Mr James Bett, factor to Lord Breadalbane, who has kindly allowed us access to plans and papers relating to the mines kept in the Estate Office.

I.—Lead Mines of Tyndrum.

1. Geological Structure of Ground.—The district we are about to notice embraces the head of Strath Fillan and the ground on the north side of the Coninish valley. It

[1] Proceedings, vol. xvi., p. 421.

is traversed by a line of fault, with a N.E. and S.W. trend, which roughly divides it into two portions. The part on the west side of the fault consists of hard, massive, slightly ferruginous quartzites, with lenticular beds of mica schist; while the less hilly country on the east side is almost entirely composed of the hydromica schist so abundant in this part of the Highland area. The section in Fig. 1 is drawn along the course of the Allt nan Sae, a stream which crosses the strike of the beds as it flows south-eastwards down the slope of the Meall Odhar towards the Coninish river. The Meall Odhar (2046 feet high) forms the central part of a ridge which trends eastwards towards Clifton, ending in the Sron nan Colan, in which the mines are situated. Immediately to the west of the Meall Odhar there is a col, on the other side of which the ground rises in Beinn Chuirn to a rugged mountain peak, which looks down on the Coninish valley from an altitude of 2878 feet.

The schists (Fig. 1) which form the eastern part of the ridge are well exposed along the bed of the Allt nan Sae for a distance of half a mile upwards from its mouth. A steadily descending section of greenish and silvery grey hydromica schist is there passed over. The dip, as the arrows on the map indicate, is to S. and S.S.E., and increases from 20° or 25° at the foot of the hill to 50° at the point where the fault crosses the stream. A felsite dyke traverses the schists a short distance below the fault, and still farther down in the stream section we have observed a bed of hornblende schist containing magnetic pyrites. The schists are veined with white quartz, which increases in quantity towards the fault.

Forming a series of picturesque cascades, over which the burn rushes, the quartzites make their appearance at the foot of the falls, where they abut abruptly against the softer mica schists. At this point the direction of hade is not very clearly indicated, but on tracing the fault northwards across the hill to the ravine adjoining the mines, the downthrow is clearly seen to be to the south-east. The quartzites thus belong to a horizon lower than that of the schists, and are probably of the same age as the Glen Lyon and Schiehallion grits. In the neighbourhood of the fault the quartzites have been shattered,

and the brecciated mass thus formed has been subsequently recemented with crystalline quartz containing grains and crystals of copper pyrites, zincblende, and galena.

From the fault to the top of the burn—a distance of nearly a mile—the section is, as before, a continuously descending one. The series which dips S.E. at an average inclination of 30° is composed of white and slightly ferruginous quartzites, with a few lenticular bands of mica schist. One small vein of barytes crosses the burn obliquely near the top, and is in turn intersected by two veins of blind quartz exposed in the bed of the stream. A few yards below the old dam, through which the stream flows, a basalt (dolerite) dyke appears on the bank, and seems to be a continuation of that on the southern side of the hill above the mines.

The "Quartz reef" or "Mother vein" of the old miners here crosses the stream and forms part of the dam wall. It runs N.N.E. and S.S.W., and appears to be vertical. Protruding through the brown peat and heather of Meall Odhar, the band of white quartz forms a well-marked feature along the southern shoulder of the hill. The outcrop is continuous for a distance of a mile and a quarter between the old dam and the northern branch of the Allt Eas Anie. The average thickness of the reef is 20 feet, and throughout its entire length is composed of unmetalliferous white quartz.

The chief workings of the Tyndrum mine are in the northern side of the Sron nan Colan. Bare of vegetation and drift, the rock surface is obscured only by occasional patches of *débris* from the various levels, and the geological structure is at once apparent. It is identical with that exposed in the Allt nan Sae which we have already noticed. The workings are bounded on the east by a deep ravine, through which runs the fault separating the hard quartzites from the less durable schists. The east side of the gully is composed of beds of a soft, greenish, spotted, mica schist, considerably corrugated and contorted. The schists dip from S. 20° W. to S. 10° E., and thus strike obliquely against the fault, while the quartzites, with a S. 50° E. dip, strike almost parallel to the line of dislocation. The quartzites, which are here very hard, have a dull brown or grey hue, and occur in beds separated by

occasional partings of mica schist, thus resembling in every respect those of the Allt nan Sae.

The mica schists are exposed in a continuously descending section to the north of Clifton. The position of the fault at this locality has been fixed by means of a "costean" made by the Scots Mining Company at the east side of the Inveroran Road, and about ¾ of a mile from the village.

2. **Geometrical Relations of** (*a*) **the Tyndrum and** (*b*) **the Coninish Veins.**—*a.* The metalliferous deposits at Tyndrum are all in veins, one of which is situated at Coninish in the S.W. corner of the accompanying map, and the remaining two in the more immediate neighbourhood of Tyndrum. Other small veins are shown on the map, but we do not propose to describe them here, as we believe them to be of no great commercial, or scientific interest.

The Tyndrum veins run, as we have already seen, through the Sron nan Colan, and the ore has been worked by means of a series of levels driven into the northern side of the hill (Fig. 3). The Tyndrum "hard vein" is in the quartzites alongside of the fault, and trends N. 35° E., while the "soft" or "clay vein" is generally in the fault fissure itself, which runs N. 40° E. This difference in direction makes the two veins converge to a point at the top of the hill above the mines. The resulting conjoint vein following the line of fault is known as the "Tyndrum Main Vein," and runs south-westwards over the southern slopes of the Sron nan Colan, across the Allt nan Sae, to the junction of the Allt eas Anie and the Coninish Water at Coninish, whence it passes out of the confines of the map.

Working plans of the mine show both veins to hade to east (Fig. 2), the hard vein at an angle of 65° to 70°, and the clay vein at 80°. This difference in hade must bring both veins together at a certain depth below the surface, and the junction has actually been reached at the end of the "New Level" shown in Fig. 3. From this point the line of junction rises diagonally upwards, and, as we have already seen, reaches the surface on the southern side of the crest of the ridge. All the richest workings were in the hard vein above this line, and, contrary to general experience, the con-

joint vein was found to contain very little ore of any value. This fact is of importance in its bearing on the future of the mineral workings at Tyndrum. The southern slope of the mine hill lies below the line of junction, and carries the crop of the united veins, so that in this direction a decrease in the quality of the ore can only be expected. So far as our observations go, this is the case, for an examination of the vein where it crosses the Allt nan Sae soon showed it to be very poor in metalliferous minerals, and indeed to be hardly deserving of the designation "metalliferous" vein at all. Some good ore has, however, been found in a costean at the place where the vein crosses the Coninish Water about three-quarters of a mile S.W. of the Allt nan Sae section.

The hard vein is intersected and dislocated by two cross courses which terminate in the west wall of the clay vein, while the united vein in the lower workings is dislocated by a third cross course. These minor cross faults have produced no important deviation in the trend of the hard vein which runs continuously northwards from the mine, maintaining its general bearing of N. 35° to 40° E., and has been traced to the top of Beinn a Chaisteil, 4 miles from Tyndrum.

b. Mining at Coninish has been carried on by two sets of openings at different parts of the vein. The most easterly of the workings are in the deep corrie in the side of Beinn Chuirn above Coninish. The vein, which is here several feet thick, runs up the rugged precipitous side of the corrie, where some of the old stopes can be seen as well as the mouths of the levels driven into the hill along its course. In the main or Beinn Chuirn level the vein consists of about 1 foot of good ore with white quartz on each side, above which the hard quartzite forms a strong hanging wall. The levels communicate with the surface by a shaft driven 470 feet upwards to the top of the cliff. The mines were abandoned about thirty years ago, and during that period so much mud and peaty matter has been washed down through the opening that the main level is nearly impassable a short distance inwards from its mouth. The other working known as the Beinn Lui[1] Level was on the Allt an Lund, 1 mile

[1] Erroneously spelt Beinn Laoigh on the Ordnance Map.

S.W. of Eas Anie. Between these two places the vein is in a true fissure with a S. 45° W. course. The Coninish vein may possibly be a south-western prolongation of the quartz reef which, towards the north, is quite barren.

3. **Distribution of Ores.**—The working plans and reports relating to the Tyndrum mines kept in the Breadalbane Estate Office show the ore in the hard vein to be distributed in four broad parallel bands, which run diagonally over the plane of the fissure at an inclination of 30° to 40°. The bands are shown on Fig. 3, which is reduced from the mining plans; between the shaded portions of the sections the ore does not altogether disappear, but becomes poor and unworkable.

4. **Composition of Veins** (1.) **Ores.**—The three veins resemble one another in having the same mineralogical composition. Argentiferous galena is the chief ore, while zinc-blende occurs in smaller quantity at each locality. The blende was never used, but was thrown aside with the "deads," and the quantity to be seen in the rubbish heaps at the mouths of the various levels shows it to have constituted a considerable proportion of the available ore. The galena is of the ordinary type, with bright metallic lustre and perfect cubical cleavage, but in the clay vein it passes into the compact or cryptocrystalline variety, known locally as "steel ore." When the clay vein leaves the fault and runs into the schists it becomes split up into small strings, and the ore deteriorates in quality, becoming disseminated through the surrounding rock.

A recent assay by Beringer of Cornwall of a sample of ore from the western slope of Tyndrum Hill gave

Lead, 28·7%.
Silver, 1 oz. 6 dwt. per ton.

The galena from the Coninish mine has a much higher percentage of silver, and is generally a richer ore. The average of two assays by Napier of Glasgow in 1863 from the Beinn Lui and Beinn Chuirn levels gave

Lead, 58%.
Silver, 8 oz. 6 dwt. per ton.

This average for the silver is probably rather high, since Beringer's assay of a sample from the Beinn Chuirn level gave

Lead, 68·5%.
Silver, 3 oz. 12 dwt. per ton.

Separate assays by both Beringer and Napier, of ore from the main vein where it crosses the Coninish river, show it to be slightly richer there than at Tyndrum. The results are as follows:

Beringer's { Lead, 58·7%.
Silver, 2 oz. 5 dwt. per ton.
Napier's { Lead, 58·25%.
Silver, 4 oz. 10 dwt. per ton.

A few other metallic minerals are known to occur at Tyndrum. Copper pyrites occurs only in very small quantities, as detached grains and crystals disseminated through the veins. Iron pyrites is found accompanying the ores, but not very abundantly, and titanic iron is stated by Thost to have been seen in the mines. Half-way along M'Callum's Level, black and red argentiferous cobalt ore (bloom?) was found in the hard vein, which at the place contained 4 inches of good ore.[1] The cobalt ore was in the centre, with sharply defined bands of galena on each side. This rare mineral only existed as a thin leaf, and exploration of the vein above and below the level failed to show its farther continuance. An assay of the black cobalt gave

28% cobalt.
60 oz. silver per ton.

A trace of red cobalt has also been found at the outcrop of the main vein on Beinn Odhar.

As secondary or decomposition minerals, we have to note calamine ($ZnCO_3$), which occurs as a white amorphous incrustation on the sides of the vein in the old workings at Tyndrum. Pyromorphite and malachite are also found as outcrop minerals at the place where the vein crosses the Eas Anie burn.

[1] F. Odernheimer, Highl. Soc. Trans., vol. vii., 1841.

(2.) **Veinstones.**—The gangue[1] is almost entirely white quartz, both in the Coninish and Tyndrum veins. Calcite occurs sparingly, and barytes accompanies the ore, but only at places where it is richest.

In the clay vein the ore is found chiefly in a black indurated fault breccia made up of schist and quartzite fragments cemented together in a matrix of crystallised quartz.

The thickness of the ore was very variable. When only 4 inches thick it could be worked to a profit, and where richest in the Stamp, Bryan, and Long Levels, it had an average breadth of from 10 to 20 inches. The hard vein had sometimes a thickness of over 4 feet, and was richest where it had a regularly defined hanging wall, *i.e.*, where it was a true fissure vein, and this, as we have seen, was only the case above the line of junction with the clay vein. The hardness and toughness of the surrounding quartzites added greatly to the cost of mining it.

5. **Mining History.**—The vein at Tyndrum was accidently discovered in 1741, during the lease of the Breadalbane minerals to Sir Robert Clifton, who, between that year and 1745, raised 1697 tons of lead ore. He was succeeded by the Mine Adventurers of England, who worked the mine for the next 15 years, producing, between 1745 and 1760, 2046 tons of ore. From 1760 till 1762 the Ripon Company mined 330 tons, and from 1762 till 1768, 942 tons were raised by Messrs Richardson & Paton.

In 1768 the lease fell into the hands of the Scots Mining Company, and during their tenure the mine was more vigorously worked. The existing levels were driven further into the hill, and the ground in the vicinity of the Inveroran Road was explored by means of two close mines, but the results did not justify further expenditure of capital. Up to this time the ore had been carried by way of Loch Lomond to Glasgow for shipment to the south, but the Scots Mining

[1] This Cornish word is derived from the German *Gang*, a term applied technically to veins and intrusive dykes, but originally meaning a *course* or *going*, and survives in the Scottish, *gang*, to go, and in the English, *gang*way. It should be purged of the superfluous and silent *ue*, and spelt in its original simple form, *gang*.

Company erected smelting works about a mile east of the mine, and produced, between 1768 and 1790, 1678 tons of lead from 3685 tons of ore, which thus gave a yield of 45 per cent.

After the time of this Company mining was carried on intermittently till 1858, when the mine was taken in hand by the late Marquis of Breadalbane and carried on till his death in 1862, when all mining operations on the estate were discontinued by the trustees.

The first companies worked the highest portion of the vein where it was found to be richest, taking out the best and leaving the poorer ore, or using it as packing. As no rolls for crushing the ore were used till the time of the Scots Mining Company, a considerable quantity of good stuff was lost by the previous lessees.

The mines have all been worked by levels as shown on the small section, Fig. 3. These were generally 4 feet wide and 6 feet high, and several of them are still open, but a good many are choked up at the mouth by the falling in of rubbish from above. The ore was removed by the usual method of overhand stoping, but occasionally underhand stoping was also resorted to. The tough quartzite formed a strong hanging wall, and in many cases large parts of the vein were removed and no support left for the roof, so that a black gaping chasm is now to be seen inside the hill between the different levels.

In the main workings, the lowest Water or MacDougall Level was laid with hutch rails the whole distance in to the face. The ore was thrown down shoots from the upper workings to this level, where it was run out to the mouth and let down to the bottom of the hill by a self-acting inclined plane, whence it was conveyed along a tramway to the stamps and smelting works about a mile distant.

6. **Remarks.**—The Tyndrum veins are all typical examples of what von Groddeck, in his valuable work on Ore Deposits,[1] has named the "Clausthal Type," from the mining town of Clausthal on the Upper Harz in Prussia. The veins be-

[1] Die Lehre von den Lagerstätten der Erze (Leipzig, 1879), § 111.

longing to this type are of various ages, and are always in stratified rocks. The ores they contain are principally argentiferous galena, zincblende, copper and iron pyrites, with quartz, calcspar, and spathic iron in all proportions, while barytes and other minerals only occur in subordinate quantities. The Clausthal Veins[1] are all in large faults traversing the Culm greywackes and shales, and the ore is often distributed in diagonal bands (Erzfälle), like those developed on a small scale at Tyndrum (Fig. 3).

The cloud of mystery with which many questions relating to the origin of metalliferous veins are involved, is both thick and heavy to lift, and although miners and engineers have been at work for the last two thousand years, and have honeycombed the earth's crust in search of the precious metals, sometimes to depths exceeding 3000 feet, all their explorations have given us comparatively little help in this department of geological research. One point, however, appears, in some cases, at least, to have been clearly established, and it is this, that *ceteris paribus*, most metalliferous matter will be deposited at those parts of the vein where the water which holds them in solution, has greatest facility for circulation. In many of the lead veins of Alston Moor on the Tyne, this law has been ascertained by W. Wallace, who has written a treatise on the subject,[2] and given many good illustrative drawings and sections of the fissures and veins in that locality. At Tyndrum the law holds good, and the reason why the vein in the quartzites is richest is probably because it is a true fissure vein in which the water could freely circulate, whereas the main vein along the line of fault has been choked up with brecciated fragments of the soft argillaceous schist, which have effectually obstructed the passage of the metallic solutions.

Whether the metalliferous matter has come up from below or down from above, or whether it has been infiltrated laterally, is an open question, as no analyses of the adjacent

[1] Described by one of the authors at page 240 of this volume.

[2] "The Laws which regulate the Deposition of Lead Ore in Veins, illustrated by an examination of the geological structure of the mining districts of Alston Moor." London, 1861.

rock have been made, nor does evidence exist in favour either of the first or of the second of these propositions. It is certain that the veins were formed after the metamorphism of the original sandstones and argillaceous shales into quartzites and schists. These rocks were metamorphosed before the Old Red Sandstone period, as breccias containing fragments of schist are found at places where the basement conglomerate of the Lower Old Red rests in violent unconformability on the upturned edges of the metamorphic series. The great faults which traverse the Highland area are very old; some of them are later than the Carboniferous period, but most, if not all, are Pre-Miocene, as the great basalt dykes which emanate from the Miocene volcanic plateau of the Hebrides run across them, or sometimes become deflected and follow their course for short distances, showing the fault fissures to have been in existence at the time of the irruption of the basalt. One of these dykes crosses the vein at the top of the Sron nan Colan (see Map). There are abundant proofs that an enormous thickness of rock has been denuded from the Highland area since Miocene times. Some of the dykes cross the country from shore to shore, passing through the tops of mountains over 2000 feet in height, and situated at no great distance from the sea coast. This shows that the valleys themselves have been produced by denudation since the time of the irruption of the basalt, and that in all probability a considerable thickness of rock has also been removed from the tops of even the highest hills. If, then, there has been such a vast denudation, the metalliferous veins now laid bare must have been formed at great depths below the surface, where heat and slow chemical processes could go on quietly, producing the results we witness to-day. It is thus obvious that the parts of the original veins now exposed, whether produced by infiltration from above, below, or the sides, have been formed at depths so great that it is a matter of indifference from which quarter the solutions came. The gaping fissures must have been quite full of liquid, as water is believed to occur in all deep-seated regions, no matter how high the temperature; and wherever the water had free room to circulate, there it has

deposited the most metalliferous minerals. What the chemical process was, is a much more difficult question, and how it has come about that there is at some places a mineral vein, and at others nothing but a barren quartz reef, is a problem to which the data at Tyndrum are insufficient to afford a solution.

II.—Corrycharmaig.

At this locality, three miles from the foot of Glen Lochay, which joins the valley of the Dochart at Killin, chrome iron ore was mined on a limited scale by the late Marquis of Breadalbane.

The workings consist of one small drift, now standing full of water, and several small open pits above. The ore is found on the south side of the glen in a mass of serpentine about half a mile in extent from east to west and three hundred yards in breadth. At the top of the hill the rock is tough and green, but is soft and white in the drift below. The mass of serpentine has an apparently bedded structure, with a W. 20° S. dip, at an average angle of 30°. As the dip of the mica schists on the hill above and below varies from S. to S. 20° W., the serpentine may possibly be intercalated between their bedding planes. The surrounding mica schists are generally garnetiferous, and in some cases contain small bands of serpentine. The chrome iron ore appears to be disseminated through the serpentine in detached grains or aggregates, and no vein is to be seen. It occurs in masses, sometimes angular, but more often reniform or lenticular in shape, and varying in size from that of a pea to blocks 5, 10, and, in one instance, as much as 30 tons in weight. Small cavities lined with minute octahedral crystals of the ore are not uncommon. The minerals associated with it are actinolite, steatite, crysotile, and magnetic and copper pyrites. From the trial workings made over this field, about 60 tons of ore were raised and sold in 1855-56, but the ground is still practically unproved. The following analysis was made by W. Valentine in 1862:

Sesquioxide of Chromium, 36·86 per cent. = Chromic Acid, 48·3 per cent.
Protoxide of Iron, . 20·27 per cent.

The ore fused with the greatest facility, and 100 lbs. would be capable of furnishing about 70 lbs. of bichromate of potash.

We have just received analysis of three specimens of the ore made in the Laboratory of the Cleveland Steel Works, 1884, which gave:

Sesquioxide of Chromium,	37·18	38·79	25·50 per cent.
Protoxide of Iron,	19·30	23·14	25·71 ,,
Protoxide of Manganese,	0·18	0·27	0·19 ,,
Silica,	10·94	11·20	17·00 ,,
Sulphur,	0·06	0·05	0·07 ,,
Phosphoric Acid,	0·06	0·05	0·06 ,,
Lime,	Trace	Trace	Trace

III.—Tomnadashan.

1. **Topography.**—The small hamlets of Tomnadashan and Easter Tullich are situated on the sloping hillside, which rises somewhat steeply from the southern shore of Loch Tay, about 2 miles north-eastward from the village of Ardeonaig, and 7½ miles S.W. from Kenmore.

Copper ore was discovered here by the late Marquis of Breadalbane, who, after mining and dressing it, had it smelted in works erected on the shore of the loch.

2. **Geology.**—The neighbouring country is almost entirely composed of nearly flat hydromica schists, with zones of limestone, hornblende rock, and grit, and is traversed by numerous dykes of basalt, porphyrite, and felsite, which serve to enliven the otherwise rather monotonous geological picture of the region.

At Tomnadashan the schists are pierced by a boss of crystalline rock, which has produced a certain amount of contact metamorphism around its edges. The metamorphic strata are baked and crumpled, and occasionally penetrated by offshoots or "apophyses" from the intrusive mass, in which fragments of the schist are sometimes completely enveloped.

The rock resembles ordinary grey dolerite externally, but microscopic examination shows that it is quite different from the true dolerites found in the long Tertiary dykes of the vicinity. It is granular throughout, quite free from green

decomposition products, and contains much brown biotite interspersed through the matted mass of beautifully striated plagioclase crystals, which, with some augite, magnetite, and occasional crystals of pyrites, make up the main portion of the rock. It may be provisionally named Kersantite or Micadiorite, till a more extended investigation shall disclose its true relationship.

It extends upwards from the shore of Loch Tay at 350 feet to the 900-feet contour, and has in turn been pierced by a rock of totally different character, veins of which ramify in countless multitudes through the older mass. The later rock is of pink colour, and the thinnest threads can be easily detected in the sombre Kersantite with which it is sharply contrasted. It is well seen on the beach a short distance westwards from the old smelting works, where it is exposed in mass, while further inland it is only represented by dykes and strings appearing at places where the rock surface has been laid bare. So far as we have observed, it never passes out of the Kersantite into the surrounding schists, as Thost asserts in his paper on the Breadalbane Mines. He states that the "porphyry" extends some three miles southwards of Tomnadashan, but has apparently confounded this rock with quartz-porphyry, dykes of which occur at places in the neighbourhood, but have no connection with the rock in question. It is a granitoid rock largely composed of pink orthoclase, with quartz, greenish brown mica, and some plagioclase interspersed through it. The character of the mica and the presence of plagioclase leads us to class it under the variety of granite known as "granitite," but sometimes the orthoclase crystals are very large, when it passes into a species of granitic porphyry. Both rocks are probably very ancient, but have been injected into the schists at a period subsequent to the time of their metamorphism.

3. **Distribution of Ores.**—Small quantities of pyrites are disseminated throughout the basic rock, but the ore appears to be developed chiefly at places near the junction of the two rocks, or, in other words, the injection of the acid rock into the basic seems in some way to have influenced the original distribution of the metallic minerals. The ore is

not concentrated in any particular vein or pocket as was supposed when the mine was being worked, but is disseminated throughout certain parts of the rock in irregular grains, strings, and bunches, from the size of a pin's head up to that of a mass two or three feet in diameter. The fault fissures which we have observed to traverse the rock are either open or are occupied by soft fault breccia, and have never been filled by any infiltration of mineral matter from the adjacent rock. Thost states, however (*loc. cit.*, 123), that in some cases they have served as receptacles for the more valuable minerals.

4. **Ores, etc.**—Copper pyrites (chalcopyrite) and grey copper (kupferfahlerz) are the ores found in greatest quantity at Tomnadashan. Iron pyrites accompanies them as usual, being generally disseminated in cubes with alternately striated sides and small pyritohedra, while thin plates and scales of molybden glance are found in quartz veinlets traversing the granitic rock, but so far as we know this mineral does not occur in the basic rock at all. Silver ore is also stated to have been found at Tomnadashan. The copper ore is principally in the granitite which, when associated with any considerable quantity of metalliferous mineral, is always more or less decomposed—a circumstance often observed in such deposits.

Galena and zincblende, so often found along with these ores, are quite foreign to this locality.

Quartz, calcspar, and spathic iron are the chief accompanying minerals, but barytes is also present in small quantities. The sides of the old workings are coated with green malachite and white stalactitic encrustations, one of which is crystallised calcspar, and the other an amorphous silicate.

5. **Mining History.**—The ore was mined for nearly twenty years before the death of the late Marquis, but no separate returns of the output have been kept.

A level was driven into the face of the hill above the old smelting works to catch the supposed vein, but the ore, as already indicated, is disseminated throughout the rock, and the vein, having consequently no existence, was never reached. Several vaulted cavities and small shafts sunk to the drift

below show the extent of the workings, which were never carried on very extensively as the mine was hardly ever able to pay its own expenses. The ore, when stamped and dressed, contained very little copper, one analysis by Professor Andrew, Glasgow, giving 3·58 per cent. copper and 30·28 per cent. sulphur, and the great cost of transporting the metal when smelted to the Glasgow market further reduced or totally swallowed up any small profits which might have been made had the present Oban and Callander Railway been in existence.

5. **Remarks on II. and III.**—The Ore deposit of Tomnadashan is essentially different from that of Tyndrum, but belongs to a type nearly related to that which includes the chrome ironstone of Corrycharmaig. In the former case the ore is in a vein in stratified rocks through which water could freely circulate, but in the latter it is disseminated throughout a rock which is not stratified, but crystalline or massive in character and igneous in origin.

The ore deposit of Corrycharmaig belongs to von Groddeck's type "Wooded Peak," named from a mountain in New Zealand, which forms part of a great tract of serpentine 80 miles long and 1 or 2 miles broad, and consists largely of this ore. The serpentine and chrome ironstone are both of the same age. The original olivine, augite, or enstatite rock, consisting largely of a magnesian silicate, contained also iron and chrome mineral ingredients, and in the process of serpentinising, the magnesian silicates became hydrated, and the other minerals underwent a different change. The original iron in the rock became separated out as magnetite, while the chrome-minerals, picotite, chromediopside, etc., were decomposed, and the chromium combined with the iron to form chrome iron ore, which is isomorphous with magnetite. It is thus useless to expect to find a true vein at Corrycharmaig, as the chrome ironstone does not occur in veins, but is disseminated throughout the serpentine in more or less concentrated aggregates, and mining in such a deposit must be always more or less precarious in character.

The same remarks are generally applicable to the copper deposit of Tomnadashan. It belongs apparently, most nearly, to a related species named by our authority "Type Med-

norudjansk," and which is defined as consisting of "inclusions of pyrites—iron, magnetic, and copper pyrites, erubescite, etc., more rarely other sulphides as galena, blende, fahlerz, etc.—in massive rocks usually in diorite, gabbro, and olivine rock (serpentine)." This definition does not fit exactly as the description we have given shows, for (1) the rock in which most of the ore occurs is not a diorite, gabbro, or olivine rock, and (2) although pyrites is most abundant, a large quantity of fahlerz or grey copper is also present, but magnetic iron or erubescite are not known to occur. The ore, as has been remarked, occurs at places where the granitic rock is decomposed, and at or near the contact with the basic rock. The metallic elements have probably been originally brought in by the later eruptive rock, as Thost remarks, and the ore, like the chrome iron in the serpentine, has been produced as a decomposition product, and along with it calcite, quartz, spathic iron, and a little barytes, all of which could have been derived from the minerals in the surrounding rock. The dark rock is not generally so much decomposed as the red, and at many places appears quite fresh, but the latter is very rarely to be seen without some traces of decomposition (*vide* v. Groddeck, §§ 80, 81).

IV.—Corrie Bui.

Argentiferous galena veins have been worked at Corrie Bui on the top of Meal na Creige, a hill 2683 feet in height, situated about 2½ miles S.E. of Ardeonaig, and 2½ miles S.S.E. of Tomnadashan. The hill is capped by a zone of calcareous schists, through which the veins run in two directions. One system contains 3 veins which run E. and W., and are nearly barren, but all the metalliferous veins have a N. and S. trend, and a steep easterly hade. Thost states that 18 such veins were crossed in a distance of 200 yards, and he had no doubt that others remained undiscovered below the turf.

The veins are of quartz varying in thickness from 4 inches to 3 feet. Spathic ironstone is also abundant, and decomposes into brown gossan by which the outcrop can easily be recognised.

Copper and iron pyrites and zincblende are rare, and the galena is thus comparatively pure. It is very valuable, as it

contains from 85 to 600 oz. of silver per ton of ore. Two small lumps of native gold were found in the quartz as it was being crushed under the hammer.

The veins unfortunately become barren as they pass down into the schists below the calcareous zone, and at a depth of 100 feet below the surface they were found to consist of white quartz alone, thus rendering all further working unproductive.

V.—Ardtalnaig.

Small veins of galena and blende have been exposed by costeaning on the side of the hill E. of Ardtalnaig,—a village on the south side of Loch Tay, about a mile N.E. of Tomnadashan, but they are far too thin to give any hope of future productiveness. The principal vein has been opened out at a spot on the hillside about 900 feet high, and due E. of Ardtalnaig where the schists are traversed by a sheet of intrusive felsite of pale cream colour and perfectly compact texture. The vein runs through the felsite, into the mica schist, and then passes again into the intrusive rock. It is interesting to note that where it is in the schist, galena and blende are both present, in a matrix of barytes and quartz, while the portions of the vein traversing the felsite contain galena and quartz but no blende.

Many other small threads and strings of ore intersect the schists around Kenmore and along the shores of Loch Tay, but none have been discovered with any approach to workable thickness.

XVIII. *The Harz Mountains: their Geological Structure and History.* By Henry Moubray Cadell, Esq., B.Sc., Edin., H.M. Geological Survey of Scotland. [Plates IX. and X.]

(Read 16th January and 20th February 1884.)

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I. INTRODUCTION.

The fame of the ancient metal mines, the many difficult problems connected with the geological structure of the range, and the fascinating beauty of the romantic valleys and vast billowy expanses of sombre pine and bosky beech—all have invested the Harz Mountains with the deepest interest, and made them a centre of attraction to travellers from many lands.

Few countries can boast of such a magnificent natural "Museum of Practical Geology" as our kinsmen of Deutschland possess in their "Harzgebirge," and the descriptive catalogues of its contents have, under their exhaustive methods of research, continued to expand and develop since von Terebra, in 1785, gave to the world his "Erfahrungen

vom Innern der Gebirge," in which the rocks of the Harz were for the first time described.

Among the great names associated with the explorations of the Harz in the past, may be mentioned those of Lasius, Freiesleben, Hausmann, Fr. Hoffmann, von Buch, Ch. Zimmermann, and F. A. Roemer, to which must be added those of our own countrymen, Murchison and Sedgwick; while the present generation is represented by such well-known "Forscher" as Lossen, Beyrich, von Groddeck, and Kayser, who find in the rocks of the Harz an ever fruitful field for original investigation and discovery.

About two years ago Professor K. A. Lossen of Berlin published a very beautiful and minutely detailed geognostic map of the Harz and surrounding country on a scale of 1 : 100,000, on which no less than ninety different kinds of rock, etc., are indicated by various colours and signs; and last year (1883) my esteemed teacher, Dr Alb. von Groddeck, Director of the Royal Mining Academy at Clausthal, issued the second edition of his little volume, "Abriss der Geognosie des Harzes," which is intended to accompany the map as an explanation, since no large descriptive memoir on the geology of the Harz has yet appeared.

With the exception of the valuable pioneering papers by Murchison,[1] and sundry casual notices in text-books and periodical journals, nothing appears to have been written in English on the Geology of the Harz Mountains; and it is now my wish to fill up, however imperfectly, this blank in our scientific literature by seeking to give an outline of the geological structure and history of that delightful region.

During my residence in the Harz, while studying for two sessions at the Royal Mining Academy at Clausthal, I had numerous opportunities of examining the geological structure of the range. Both in the lecture-room and in the weekly excursions to the metal mines or to field sections, I enjoyed the pleasure of listening to Dr von Groddeck's valuable exposition of the Geology of the Harz. But in addition to these excursions, I made a series of independent traverses

[1] See Appendix.

across the chain, the results of which may help to throw light on its geological history.

II. TOPOGRAPHY OF THE HARZ.

The Harz[1] is the highest mountain range in North Germany. It is situated between the Weser and the Elbe, about 125 miles south of Hamburg, and extends from N. lat. 51° 30½′ to 51° 57½′. It rudely resembles the segment of a circle, whose chord extends for a distance of about 56 miles in an E.S. and W.N.W. direction, thus following the general trend of the adjacent ranges. This peculiar configuration is entirely due to the geological structure of the ground, as a glance at the accompanying sketch-map will show. The maximum breadth of the Harz is about 20 miles (British),[2] and the area 786 square miles, of which 457 belong to Prussia, 286 to Brunswick, and 43 to Anhalt.[3]

Like the Alps, Pyrenees, and Himalayas, the Harz is, as we shall afterwards see, a mountain system of elevation, and not a tableland of denudation like Norway or our own Highlands. It consists of a central mass—the Brocken, 3746 feet (1142 m.)[2] high—with several surrounding heights of lesser magnitude, which in the western division, drained by the Weser, form the plateau of the Upper Harz (2100 feet); and in the eastern, drained by tributaries of the Elbe, the featureless uplands of the Lower Harz, whose average height is about 1600 feet. Along the northern boundary line, which has been compared to the chord of the arc, the mountains rise abruptly from the rolling plain of Secondary and Tertiary formations, which, at the foot of the Harz, has a height of 700 or 800 feet. The southern and western boundaries are also well marked, but the eastern part of the Lower Harz, in the neighbourhood of Mansfeld, slopes away, and almost imperceptibly loses itself in the adjacent country.

The principal towns on the Upper Harz are Clausthal and

[1] Spelt also Hartz (from Hart—forest land), *Sylva hercynia* of the Romans.

[2] 1 kilometer = 0·62 British statute miles; 1 British mile = 1·61 kilo; 1 meter = 3·2809 ft.

[3] Encyc. Brit., 9th edit.

Zellerfeld, Grund, Wildemann, Lautenthal, Altenau, and St Andreasberg; and on the Lower Harz, Elbingerode, Benneckenstein, Ilfeld, Hasselfelde, Stolberg, and Harzgerode.

The Kyffhäuser is an isolated hill situated a few miles from the southern edge of the Harz, close to the village of Kelbra, which, but for its geological interest, would not have been alluded to here.

III. GEOGNOSY OF THE HARZ.

1. Archæan Rocks of the Kyffhäuser.

The red Permian sandstones and conglomerates of the Kyffhäuser rest on a basement of gneiss, a small patch of which is seen peeping out along the N. side of the range to the S.E. of Kelbra. The gneiss is highly crystalline and sometimes granitic, and strikes in an approximately E. and W. direction. It is associated with a beautiful highly hornblendic diorite and a variety of very hornblendic syenite, containing much sphene. The numerous granite veins by which it is intersected are probably connected with a main mass beneath, part of which is exposed on the face of the hill immediately below the Kyffhäuser tower. The geological structure of this eminence is shown on section No. 2. The age of the gneiss cannot be definitely fixed, as the requisite data are awanting, but in petrographical character it most nearly resembles the Archæan gneiss of other countries, and is meanwhile relegated to that formation.

2. "Kerngebirge," or older Palæozoic Core of the Harz.

a. Hercynian.

The oldest rocks of the Harz were formerly classified at Upper Silurian, as they contain graptolites and other Silurian forms. More recent researches, however, have led to their being placed under a separate group, occupying a position intermediate between Silurian and Devonian. This group is named from the Harz "Hercynian," and corresponds to Barrande's Étages, F, G, H, of the Bohemian basin.

The Hercynian Rocks are thus classified:

(2.) Lower Wiederschiefer, . .	Upper (Graptolithenschiefer zone). Lower (Kalk-Grauwacken zone).
(1.) Tanner Greywacke, . . .	Oldest rock of the Harz.

(1.) The Tanner greywacke is usually fine grained, and occurs in thick beds with thin shaley intercalations. It contains plant remains, *Knorria, Sagenaria, Lepidodendron, Archæocalamites,* and, according to Kayser, some corals and crinoid stems.

(2.) To these rocks succeeds the lower division of the Lower Wiederschiefer. This group consists of shales, with greywacke beds containing plants; also whet slates, kieselschiefer,[1] and lenticular fossiliferous limestones, which are sometimes of workable thickness. The limestone is of two kinds—a compact splintery siliceous variety, and a granular sparry variety. The former is characterised by containing cephalopods, and the latter by its brachiopods. The fauna is Devonian, and is represented in the genera *Gyroceras, Goniatites, Cryphaeus, Terebratula, Spirifer, Amplexus,* and *Pleurodictyum.*

The whet slates, or "Wetzschiefer," are yellowish or greenish-grey homogeneous silicified clay slates, with microscopic mica scales, yellowish-green microliths, tourmaline needles, and sometimes abundance of garnets.[2] The Kieselschiefer will be noticed under the Culm Rocks.

The Upper or Graptolite shale group consists of clay slates charged with crinoids, orthoceratites, and, towards the top of the series, with graptolites, which have not been found on any other horizon in the Harz.[3] It is interesting to note

[1] "Schiefer" in German relates to geometrical form, and is applied to a great variety of rocks with a lamellar, tabular, or flakey structure, due either to bedding or to cleavage (Schieferung). Thus: Thonschiefer (clay slate), Schieferthon (argillaceous shale), Dachschiefer (roofing slate), Glimmer-, Hornblende-, etc., schiefer (mica-, hornblende-, etc., schist), Kieselschiefer (flinty shale), Kupferschiefer (copper shale), etc., etc. The German language, so often more expressive than the English, is in this case less so.

[2] H. Credner, Elemente der Geologie, 4th edit., 1878, pp. 108, 119.

[3] See K. A. Lossen, Zeitsch. d. d. geol. Ges., Bd. xxi., p. 284; Bd. xxvi., p. 206; xxvii., p. 454. E. Kayser, Die Fauna d. ältest. Devon Ablagerung d. Harz, p. 210.

that the graptolites do not occur in the lowest beds, but are found at the very top of the Hercynian series. Might I suggest the possibility of these graptolites having migrated as a colony from some other area during the deposition of this formation? In our Scottish Old Red Sandstone of Lanarkshire a similar case occurs in the shape of a single graptolite found in a thin band of shale about 5000 feet above the base of the system.[1]

The granular diabase generally associated with the Upper Hercynian strata, is noticed under the palæozoic volcanic rocks at p. 244.

b. Devonian.

The Devonian rocks rest conformably on the Hercynian, and are, on the Harz, as at other places in Europe, palæontologically divisible into three groups—(1.) Lower, (2.) Middle, and (3.) Upper.

(1.) The Lower Devonian rocks of the Harz are of two facies—the "Upper Harz facies" and the "Lower Harz facies."

The Upper Harz facies is represented (1st) by a set of apparently unfossiliferous quartzites, forming the Bruchberg, a high ridge running from the Brocken south-westwards to the edge of the Harz near Osterode; and (2d) by a series of fossiliferous sandstones, well developed, between Clausthal, Goslar, and Ocker, where they form the Rammelsberg, Bocksberg, Kahleberg, etc. This rock is named the "Spiriferensandstein," from the numbers of spirifers it contains.

Thè fossils which characterise the Spiriferensandstein are:[2]

Ctenocrinus decadactylus.	*Rhynchonella Orbignyana.*
Cyathocrinus pinnatus.	*Pterinea fasciculata.*
Tentactulites scalaris.	*Nucula Krachtae.*
Spirifer macropterus.	*N. securiformis.*
S. cultrijugatus.	*Cardinia Vetusta.*
S. speciosus.	*Orthoceras planiseptatum.*
S. curvatus.	*Phacops latifrons.*
Chonetes sarcinulata.	*Homalonotus Gigas.*
C. dilatata.	Etc., etc., etc.

[1] A. Geikie, Text-book of Geology, p. 714.

[2] v. Groddeck, Abriss der Geognosie des Harzes, 2d edit., p. 91.

The Lower Harz facies of the Lower Devonian has been divided into five sub-groups:[1]

5. "Elbingeroder Grauwacke," . . .	Typical thick-bedded greywacke, with few plants developed chiefly on the E. and S. flanks of the anticline. At Ballenstedt, Elbingerode, and to N. and E. of Ilfeld.
4. "Zorger Schiefer," . .	Small group of clay slates, like the Wiederschiefer, often greenish or red like Wetzschiefer. Intercalated greywacke and Kieselschiefer beds, and sheets of diabase. Zorge, and W. of Stiege.
3. "Hauptkieselschiefer," .	Typical black splintery Kieselschiefer, with thin beds of clay slate. Stiege, Benneckenstein, Lauterberg; also to N.E. of Harzgerode, and on N. side of the Elbingerode basin.
2. "Obere Wiederschiefer,"	Like the Lower Wiedersch. At places red and green variegated (= Buntschieferzone); sheets of diabase and green shale at top. Güntersberge, Elbingerode basin, and between Hettstedt and Breitungen.
1. "Haupt Quarzit" (base),	On S. and E. of the anticlinal axis of the Tanner gr., unfossilif., and not calcareous. On N. of axis often fossilif. with fauna of Spiriferensandstein. S. and E. of Harzgerode, Güntersberge, Elbingerode basin.

(2.) The Middle Devonian of the Upper Harz is represented by (1st) a series of thin argillaceous limestones interbedded with shales, which rests on the Spiriferensandstein, and is named the "Calceolaschichten" (Calceola beds), from the abundance of the typical Middle Devonian coral *Calceola sandalina* which it contains. *Cupressocrinites Urogalli* and *Spirifer speciosus* are also characteristic of the group. Other common fossils are *Cyathophyllum vermiculare, Favosites Goldfussi, Fenestella explanata,* and *Phacops latifrons.* (2d) The so-called "Goslar shales," with few limestone and greywacke beds, developed near Goslar. The most characteristic fossils are:

Tentaculites conicus.	*Goniatites lateseptatus.*
T. annulatus, etc.	*G. bicaniculatus.*
Cardiola retrostriata.	*G. retrorsus.*
Orthoceras multiseptatum.	*G. Jugleri.*
Bactrites carinatus.	*G. lamed.*
Acidaspis horrida.	*Phacops latifrons.*

In the Elbingerode basin, on the Lower Harz, the Middle Devonian rocks are represented by the "Stringocephalenkalk"

[1] *Loc. cit.*, p. 30.

series of limestones, with beds of tuff and ironstone. The characteristic fossil is *Stringocephalus Burtini.* It is here associated with *Calceola sandalina,* but on the Upper Harz the Stringocephalus is only found in a thin bed between the diabase sheets extending from Altenau to Osterode.

(3.) The normal Upper Devonian series of the Upper Harz is represented by the so-called Intumescens beds, or Kramenzelkalk, over which lie the Cypridina shales. These beds are best developed round the edges of the Goslar shale area south of Goslar. The Kramenzelkalk is a compact grey argillaceous limestone, with thin shale beds and few fossils. The most important is *Goniatites intumescens;* other forms are *G. bicanaliculatus, G. retrorsus, Cardiola retrostriata, Arca Clymeniae,* and *Phacops laevis.*

The Cypridina shales are developed principally between Langelsheim and Lautenthal. They are greenish, yellowish, or red in colour, and have occasional limestone nodules. The shales are often spotted with the little shells of *Cypridina serrato-striata,* from which they are named. A few other forms occur, including *Posidonomya venusta, P. striata-sulcata,* and *Phacops cryptophthalmus.*

The Upper Devonian of the Elbingerode basin consists of limestones and calcareous beds, with *Rhynchonella cuboides, Terebratula elongata,* and *Spirifer disjunctus* (*Verneuili*), and beds of diabase tuff (Schalstein).

The chief limestone of the Upper Devonian series is named the "Ibergerkalk," from Iberg, a hill on the Upper Harz, near Grund, a village 7 kilos W. from Clausthal. The Iberg and Winterberg are parts of a great isolated boss of Devonian limestone, which rises through the overlying Culm strata. It is almost totally unstratified, and is very rich in corals. The limestone is honeycombed by a vast number of caverns and fissures, some of which contain deposits of ironstone, etc., and others are open to visitors (*e.g.*, Baumanns- and Bielshöhle, near Rübeland, Lower Harz). In the Baumannshöhle many bones of cave animals have been found, such as cave bear, cave dog, hyæna, cat, horse, etc. The limestone of the Iberg rises through the Culm greywackes and shales, which are folded and crumpled round

its sides, to a depth of about 1300 feet (400 m.) below the summit—a fact which appears to point to its having formed a massive resisting body, while the more pliable sedimentary strata around it were bent about during the great earth movements which took place in the middle of the Carboniferous period.[1]

This great Devonian coral reef contains, besides many corals (as *Ascervularia*, *Cyathophyllum*, etc.), other fossils in great numbers, *e.g.*:

Terebratula elongata.	*Rhynchonella cuboides*, *R. Pugnus.*
Spirifer simplex, *deflexus*, *bifidus.*	*Orthis striatula.*
Goniatites Wurmii.	*Conocardium trapezoidale.*
G. intumescens.	*Spirigera concentrica.*

Also many species of *Natica*, *Turbo*, *Pleurotomaria*, *Loxomena*, etc.

Dr von Groddeck, in his paper just alluded to, notes the striking resemblance between the Iberg rock and the Devonian limestone at Freiburg in Lower Silesia, which also rises like an island through the overlying Culm greywackes and shales.

The dimensions of the Lower Devonian series are not known, but the Middle Devonian beds have been found in the Bockswiese mine north of Clausthal to have a thickness of about 100 feet (30 m.), and the Upper Devonian Kramenzelkalk and Cypridina shales a thickness of 525 feet (160 m.). My best thanks are due to Professor von Groddeck, who has kindly supplied me, since leaving Clausthal, with these figures, as well as with other information which I was unable to obtain during my residence there.

c. Culm, or Lower Carboniferous.

The Culm is developed on the Upper Harz only, where it forms the plateau on which Clausthal is situated, and extends round the west end of the mountains by Seesen to Langelsheim. It is subdivided thus:

(3.) { Upper or Grund greywacke.
Lower or Clausthal greywacke, thickness at least 1300 feet.

(2.) "Posidonomyenschiefer" and Culm limestone, 425 feet.

(1.) { Kieselschiefer with adinole beds. Whet slates, greywacke and lenticular limestones, resting conformably on the Upper Devonian, 100 feet.

(1.) The kieselschiefer, or lydian stone of the Harz, is a

[1] von Groddeck, Jahrbuch der königl. preuss. geol. Landesanstalt, 1882, p. 55.

compact, very hard, infusible, hornstone-like siliceous rock, with splintery fracture and dark colour, and is impregnated with carbonaceous material and iron oxide. It occurs in beds made up of layers from 1 to 4 inches in thickness, and is traversed by numerous joints, and veined with quartz. The kieselschiefer, whet slates, and adinole beds of the Upper Harz have been described minutely by Dr F. Wunderlich,[1] who has given an elaborate account of their chemical and mineralogical characters. The following analyses of these three rocks made by him (*loc. cit.*, pp. 30, 31) give a good idea of their average composition:

	A. Kieselschiefer.	B. Adinole.	C. Whet Slates.
SiO_2,	92·482	77·278	74·839
Fe_2O_3,	0·555	0·749	0·960
FeO,	0·700	1·278	1·348
Al_2O_3,	2·537	10·209	13·284
MnO,	—	(1·240)	1·055
CaO,	1·359	1·667	1·289
MgO,	0·324	0·454	0·420
K_2O,	0·544	0·925	1·174
Na_2O,	0·541	4·397	2·610
P_2O_5,	Trace	(0·284)	(0·132)
$CuFeS_2$ (copper pyrites),	0·034	Trace	0·227
Cl,	0·052	0·044	(0·039)
C,	0·556	0·134	0·168
H_2O,	1·746	2·771	2·878
	101·430	101·430	100·423

Besides these constituents, traces of TiO_2, FeS_2 (iron pyrites), and Sb_2S_3 occur in each rock. SO_3 occurs in a few cases, and some of the specimens of B and C contained a large quantity of $CaCO_3$. A is the average of five, and B and C of six analyses. Figures in brackets indicate that the material in question has not been found in all cases.

The adinoles are distinguished chemically from the kieselschiefer by the larger quantity of alkali they contain, which renders them easily fusible before the blowpipe, while the kieselschiefer are infusible. The variegated banded appear-

[1] Mittheilungen des Berg- u. Huttenmännischen Vereins "Maja" zu Clausthal, 1880, pp. 1-95.

ance of the former renders them easily distinguishable by the eye.

The Kieselschiefer beds are, in almost all the cases I have seen, intensely crumpled and bent into sharply-defined folds, in a way which shows them to have been quite plastic at the time of their contortion.

(2.) The "Posidonomyenschiefer" are ordinary dark blue or grey argillaceous shales ("blaes" of the Scottish miner), with many impressions of *Posidonomya Becheri.* Other characteristic forms are *Orthoceras striolatum, Goniatites crenistria, G. mixolobus.* Plant remains are rare in this group. Small beds of limestone occur in these shales at some places. On the south side of the Iberg blocks of a dark limestone are found, containing the following Carboniferous fossils:

Terebratula contraria.	*Productus cora.*
Inoceramus carbonarius.	*Goniatites crenistria.*
Phillipsia alternans.	

There are also patches of quartzite between the Clausthal greywacke and the Devonian limestone of the Iberg, which contain carboniferous limestone fossils, and are regarded by Kayser and others as silicified carboniferous limestone. This limestone appears to have been formed as isolated patches in the neighbourhood of the boundary between the Iberg limestone and the greywacke.[1]

(3.) The greywackes forming the highest division of the Culm are typically developed around Clausthal. They are very rich in felspars, and the sandy, thin bedded varieties, externally resembling fine-grained sandstones, are apparently richer in plagioclase than quartz. Many of the coarse-grained greywackes resemble metamorphic granites, and must be classed as arkose.[2] The greywacke of the Harz is a poor building stone, partly because it is difficultly cut into suitable blocks, and partly on account of its hygroscopic character.

It is in these beds that the Culm flora occurs. The plant

[1] Zur Kenntniss des Oberharzer Culm. Jahrbuch der königl. preuss. geol., Landesanstalt, 1882, p. 60.

[2] *Ibid.*, p. 65.

remains are neither very abundant nor perfect. The most characteristic species are—

Calamites transitionis.
,, *Roemeri.*
Lepidodendron Veltheimianum.
,, *hexagonum.*
Knorria Jugleri.
,, *fusiformis.*
Bornia scrobiculata.

The Upper or Grund Greywacke is a conglomeratic rock, with pebbles of white quartz, quartzites, granites, and quartz porphyries—all of a kind unknown either among the older rocks of the Harz, or among those of the surrounding ranges.

3. Border Rocks (Randgesteine).

d. Coal Measures (*Obere Steinkohlenformation*).

The coal measures are represented at Meisdorf on the northern Harz border, near Ballenstedt (see section No. 1), and at Grillenberg and Ilfeld on the southern. The series at all three localities is very thin, and rests in violent unconformability on the upturned edges of the Devonian rocks. At Ilfeld, where it has been best explored, the series consists of a basement conglomerate of grey colour, containing completely rounded egg- to head-sized pebbles and boulders of greywacke, kieselschiefer, and occasionally quartzite, with intercalations of red and brown arenaceous shale and sandstone, above which come the true coal-bearing strata. These are principally sandstones and plant-bearing bituminous shales, resting on a bed of grey conglomerate, and containing a workable coal-seam in three divisions, whose thickness is generally 4 to 5 feet, but sometimes amounts to 7 or 8 feet (Prus.). The roof of the coal-seam consists generally of thin fissile red or grey shale, or conglomerate made up of subangular fragments of Hercynian rock. It is found at some places near Ilfeld to cover the coal unconformably; and for this and palæontological reasons has been relegated to the overlying New Red or Rothliegendes formation.[1]

[1] See article on the Coal formation in the neighbourhood of Ilfeld in the *Colliery Guardian*, Nov. 12, 1875, pp. 713, 714; also C. F. Naumann über die geognostischen Verhältnisse des Melaphyr Gebietes von Ilfeld, Leonhard u. Bronn., Jahrb., 1860, pp. 1-35; also Geinitz Dyas, ii., p. 198.

The coal and subordinate strata extend as a narrow band from Vatersteine, behind the old castle of Hohenstein, to Neustadt, then onwards by Ilfeld across the Behrethal to the Kunzenthal, near Rothensütte—a total distance of some 16 miles. The series, which dips away from the mountains, thus lies in a great bay in the old "core" rocks, which have here formed part of the ancient margin of the Carboniferous sea.

The flora of this district is characterised by the abundance of its ferns, which leads to its being correlated with the highest of the German coal strata. Forty-six species of plants are known to occur at Ilfeld. A list of the flora is given in the article in the *Colliery Guardian* just referred to.

e. Permian (*Dyas*).

The strata above the coal-seam are at some places unconformable, and contain a slightly different flora from that which is furnished by the bituminous shales associated with the coal itself. The division is, however, by no means very sharply defined; but Murchison, Sedgwick, and F. A. Roemer of Clausthal were of the opinion that the coal-seam is of Carboniferous age, while all the overlying red rocks belong to the Lower Permian or Rothliegendes group, and most geologists are inclined to adhere to their views.

The strata above the coal, which are of no great thickness, are covered by a thick bed of basalt, over which comes a series of variegated shales and sandstones, reaching occasionally a thickness of 100 feet, and containing the Permian plants *Walchia piniformis* and *Odontopteris obtusiloba*. These beds are in turn overlaid by a great bank of interbedded porphyrites, which at Ilfeld represent the whole of the Lower Rothliegendes series. The porphyrites are red and amygdaloidal, and often very much decomposed.

At Ilfeld the remainder of the Rothliegendes is occupied by sandstones, tuffs, and conglomerates, which have generally the red hue characteristic of the series, but become grey towards the base of the Zechstein.

The Rothliegendes is typically developed at Mansfeld, where it has the following two divisions:

Upper,	Basalt (Melaphyr) tuffs and amygdaloids, with quartz-porphyry conglomerates with basalt pebbles. Dark red sandstones resting on angular grained sandstones, with silicified coniferous stems.
Lower,	Red shales and clays, with hard fine sandstones and beds of "horn-quartz conglomerate," 10 to over 20 feet thick. Two or three beds of argillaceous unfossiliferous massive limestone, each about 8 feet thick. Brilliant red, fine sandy clays at base over carboniferous rocks. Sandstones, shales, and limestones along S. border of Harz. Basalt and porphyrite eruptions during this period.

The so-called "horn-quartz conglomerate" is made up of nut- to head-sized pebbles of grey quartz, oval or round, quite smooth, and very compact and hard. They are usually found in a loose red clay matrix, from which they are easily detached to be used as road-metal. These alternate with other fine conglomerates, containing bean-sized pebbles of jaspery rock or kieselschiefer. No granite pebbles occur in the Rothliegendes.

The Rothliegendes is not usually very fossiliferous, and bespeaks a period in which the waters were by no means conducive to animal existence. The land plants which occur are of the usual Permian type, chiefly Cycads, Conifers, Ferns, and Calamites, with a few Lycopods. Silicified stems of tree-ferns (*Psaronius* and *Tubicaulis*) and conifers are abundant at some localities. On the Kyffhäuser there are many such stems 2 or 3 feet in diameter, and sometimes 30 feet in length, lying embedded in the red sandstone of the Upper Rothliegendes.

e^1. Zechstein.

From a palæontological point of view, the Zechstein forms part of the Permian series, but geologically it deserves a separate place in the list of formations, as it indicates a great change in the physiography of the region. The southern and eastern flanks of the Harz are classic localities for the study of the Zechstein, which has there acquired a world-wide interest from its seam of copper shale—the celebrated Kupferschiefer of the Mansfeld basin—and from its great beds of anhydrite, gypsum, and dolomite, which form lines

of imposing escarpment facing the mountains, and remind the spectator of the white chalk-cliffs that girdle the southern shores of Britain.

The Zechstein is here divisible into three lithological groups :

(3.) Upper,	Developed at Mansfeld, and along south border of the Harz.	
	8. Tough brown or blue clays, alternating with thin beds of yellowish limestone and dolomite.	
	7. Gypsum without anhydrite (younger gypsum).	
(2.) Middle,	Developed all round the Harz.	
	6. Dolomite, fœtid limestone, and shale.	
	5. Dolomite, granular and sandy (Asche), and porous and coarse (Rauchwacke).	
	4. Anhydrite and gypsum, with rocksalt beds (older gypsum).	
(1.) Lower,	3. Zechstein.	Always occur together.
	2. Kupferschiefer.	
	1. Zechstein conglomerate (Weissliegendes) resting on Rothliegendes.	

The so-called "Weissliegendes" (white layer) or Zechstein conglomerate occurs in the Mansfeld district conformably on the top of the Rothliegendes; but at Ilfeld and other places a discordance has been observed between the two groups. It is a greyish conglomerate, with pebbles of decomposed greywacke, kieselschiefer, and quartz in a calcareous matrix. Pebbles of the volcanic rocks of the Rothliegendes do not occur in this bed. It occurs along the southern border of the Harz and on the Kyffhäuser, and has a thickness of from 3 to 6 feet. In the Mansfeld district between Eisleben and Hettstedt it is represented by a bed of coarse grey round-grained sandstone, 1 inch to 6½ feet in thickness.

The Kupferschiefer seam will be described under the Metalliferous Deposits of the Harz.

The Zechstein proper is a compact, yellowish or greyish argillaceous limestone, with flat conchoidal fracture, and is the most persistent of all the beds accompanying the seam. It is usually in this district 15 to 35 feet thick, and is well seen in the Mansfeld shale workings. In the lower portion of the Zechstein, *Productus horridus* (Sow.) and *Spirifer undulatus* (Sow.) are the characteristic brachiopods. Higher up come *Fenestella retiformis* (Schloth.), *Schizodus obscurus* (Sow.), *Gervillia ceratophaga* (Schl.), *Avicula speluncaria* (Schl.), *Pecten pusillus* (Schl.), *Terebratula elongata* (Schl.),

Camarophoria Schlotheimi (Buch.), *Strophalosia Goldfussi* (Münst.), etc.

It is the Gypsum of the Middle Zechstein (older gypsum) that forms the white cliffs at Osterode. In the Mansfeld district it occurs lenticularly, and has been passed through in the various shafts sunk to the Kupferschiefer, but thins out and does not make much appearance towards the edge of the basin at the outcrop of the seam. Wherever the gypsum occurs, subsidences of the surface take place, from the falling in of subterranean cavities where the gypsum or the local rocksalt beds it contains have been dissolved away by percolating water. Many such cavities have been struck in the Mansfeld shale workings.

The so-called "Rauchwacke" is supposed to have been produced by the expansion accompanying the hydration of the anhydrite. The increasing volume of the gypsum thus formed would shatter the overlying dolomite, and convert it into the brecciated, porous mass, called by the Mansfeld miners "Rauh-" or "Rauchwacke," from its rough feeling to the touch. The Rauchwacke has a thickness of from 6 to 65 feet, and contains the following fossils: *Mytilus Hausmanni* (Goldf.), *Gervillia ceratophaga* (Schl.), *Schizodus obscurus* (Sow.), etc.

The great masses of Rocksalt, which occur along with the anhydrite and gypsum, reach an enormous development at Stassfurt and Schönebeck, and have recently been found to exist in workable quantities at Aschersleben, near the eastern end of the Harz, and at Vienenburg, a village opposite the base of the mountains at Harzburg. The bottom of the great salt bed at Stassfurt has not yet been reached, but borings have proved it to have a thickness of at least 1600 feet (490m.).[1]

f. Trias.

It is not my intention to do more than give a general glance over the Secondary rocks, as they are more interesting to the palæontologist than to the geologist, and do not differ

[1] See H. M. Cadell on "The Salt Deposits of Stassfurt" (Trans. Edinb. Geol. Soc., vol. v., 1884).

greatly from those of the British Isles. The German Trias is, as its name implies, divisible into three well-marked groups. It is found all round the Harz.

(3.) Keuper, . .		Variegated clays and marls, with sandstone and gypsum.
(2.) Muschelkalk,	Upper,	Limestone, with *Ammonites* (*Ceratites*) *nodosus*. Limestone beds and clays below oolitic limestone, with *Terebratula vulgaris*, *T. trigonella*, *Lima striata*.
	Middle,	Dolomitic marls, with some gypsum; no fossils.
	Lower,	"Wellenkalk" and "Schaumkalk," with *Encrinus liliiformis*, *Turritella scalata*, *Turbo gregarius*, *Trigonia lævigata*, etc.
(1.) Bunter, . .		Chiefly reddish or variegated sandstones, with beds of roestone, gypsum, and rocksalt, almost unfossiliferous. *Posidonomya Germari*.

Large beds of rocksalt occur in the German as well as in the English Trias. A thick bed occurs at Schönebeck between the upper and middle divisions of the Bunter, as well as that between the Zechstein and Lower Bunter, already alluded to.

g. Jura.

The Jurassic Rocks are developed in a narrow band along the northern boundary of the Harz, and are divided into (1.) Lias or Black Jura; (2.) Dogger or Brown Jura; and (3.) Upper or White Jura.

(1.) The Lias or lowest division is classified chiefly by its Ammonites.

Upper Lias, . .	9. Clayey marls with *Am. radians*, *striatus*, *Bel. tripartitus*.
	8. Bituminous marls: *Am. serpentinus*, *communis*, *Posidonomya Bronni*, *Avicula substriata*, etc.
Middle Lias, .	7. Dark plastic clays: *Am. Amaltheus*, *spinatus*, *Inoceramus substriatus*.
	6. Clay marls and grey oolitic limestones: *Am. capricornus*, *A. curvicornus*, *fimbriatus*, *Belem. paxillosus*, *umbilicatus*, *clavatus*, *breviformis*.
	5. Oolitic limestones and red ironstones: *Am. brevispina*, *Jamesoni*, *Terebratula numismalis*, *Spirifer rostratus*.
Lower Lias, . .	4. Grey and blue clays with ironstone and limestone geodes: *A. planicostata*, *A. ziphus*, *obtusus*.
	3. Dark blue tough clays and red ironstone beds (worked at Harzburg): *Am. Bucklandi*, *Gryphæa arcuata*, *Spirifer Walcotti* (="arietes beds").
	2. Zone of *Ammonites angulatus*.
	1. Yellowish clays with intercalations of sandy limestone: *Am. Johnstoni* (Sow.) = *Spilonotus plicatus* (Quenst.).

(2.) Above the Lias comes the Dogger or Brown Jura,

which is also chiefly indebted to the Ammonites for its arrangement into the following 8 zones :

8. Clays with *A. Jason, Athleta, Lamberti, gryphæa dilatata, Bel. canaliculatus.*
7. Kelloways rock : *A. macrocephalus, funatus,* etc.
6. Cornbrash, small piece not in place, with *Avicula echinata.*
5. Beds with *Ostrea Knorrii, Am. ferrugineus, Parkinsoni, Astarte pulla.*
4. Clays with brown ironstone : Zone of *Am. Parkinsoni, Terebrat. varians, Ostrea explanata, Trigonia costata, Pholadomya Murchisoni.*
3. Zone of *Am. coronatus,* doubtful.
2. Clays with sphærosiderite nodules : *Inoceramus polyplocus, Pholadomya transversa,* etc.
1. Dark clays with sphærosiderite nodules : Zone of *Am. opalinus, Trigonia navis, Nucula Hammeri.*

(3.) The Upper or White Jura contains the Oxford Clay, Coralrag and Kimmeridge beds, and is richly fossiliferous. The various subdivisions of the Jurassic series do not occur with very great persistency, as they often thin out and disappear at some places, reappearing again at others.

The following are the palæontological groups into which the Upper or White Jura is divided :

Upper Oxford group.	4. Kimmeridge group, very fossiliferous.	*f.* Unfossiliferous marly limestone overlaid by cryst. limestone, 30 ft.
		e. Marls with *Astarte* and *Cerithium,* 25 to 30 ft.
		d. White compact marly limestone, 20 to 30 ft. *Tereb. subsella, Pecten comatus, Pholadomya multicostata,* one specimen of *Exogyra Virgula.*
		c. Dolomitic limestone, 10 to 15 ft., with *Pteroceras Oceani, Ponti,* etc., etc.
		b. Marls and marly limestone, 20 to 30 ft., with *Gresslya Saussurii, nuculæformis, Chemnitzia abbreviata, Natica globosa, dubia, macrostoma,* etc.
		a. Marly limestone, 10 ft. *Terebratula humeralis.*
	3. Coralrag.	*g.* Yellow grey marl, 5 ft., with *Exogyra spiralis, Rhynchonella pinguis.*
		f. Limestone, 4 ft., with *Nerinea* (*N. visurgis ?*).
		e. Oolitic marly limestone, 2 ft., *Exogyra spiralis, Mytilus furcatus.*
		d. Dark grey marly limestone, 4 ft., very fossiliferous. *Cidaris crenularis, florigemma, Rh. pinguis, inconstans, Diadema subangulare.*
		c. Grey stratified clay, 2 to 3 ft.
		b. Laminated marly limestone, 3 to 4 ft.
		a. Yellow coarsely oolitic marly limestone and marl, 15 ft. *Exogyra lobata, Pecten articulatus, Pleurotomaria suprajurensis, Terebrat. trigonella.*

Lower Oxford group.	2. Limestone, 1 to 2 ft., full of corals, especially *Astrea helianthoides.*
	1. Marly limestones, with *A. cordatus, A. biplex, Gryphœa dilatata.*

h. Cretaceous.

The Jurassic rocks around the Harz are covered conformably by the basement beds of the Cretaceous system, which is only found on the north side of the range.

The Cretaceous system is divisible here, as elsewhere in Germany, into 5 main groups: (1.) Neocomian (or Hils), and (2.) Gault (Lower Chalk); (3.) Cenomanian; (4.) Turonian; and (5) Senonian (Upper Chalk). There is no representative of the Wealden in the neighbourhood of the Harz.

The Hils conglomerate and limestone form the base of the system, and are covered by the Hils clay—a bed of loose glauconitic sands with clays and marls. The conglomerate consists of little pebbles of limonite—the Bohnerz of the Germans—which also occur in the Hils clay, and sometimes form workable beds. The conglomerate at places fills worm tubes which extend 1 or 2 inches downwards into the limestone of the Kimmeridge group. The Hils limestone contains among others the following fossils:—

Toxaster complanatus.
Terebratula multiformis, oblonga.
Exogyra sinuata.
Ostrea macroptera.
Pecten crassitesta, etc.

The Gault which overlies the Neocomian is well represented along the base of the Harz, especially near Langelsheim and Goslar, where it divides itself into the following lithological groups:—

(*c.*) "Flammenmergel," dark grey clay marls with white flame-shaped streaks. Numerous fossils: *Avicula gryphœoides, Solarium ornatum, Ammonites inflatus, A. Mayorianus.*

(*b.*) Clays and Marls, variegated and glauconitic: *Belem. Listeri, Avicula gryphœoides, Pycnodus.*

(*a.*) Gaultsandstone (Lower Quader sandstone), a white or yellowish brown, very soft, finegrained, almost unfossiliferous rock. Quarried for sand to E. of Goslar.

The Neocomian and Gault are classed as Lower Chalk (Untere Kreide) and the Cenomanian, Turonian, and Senonian as Upper Chalk (Obere Kreide).

The Upper Chalk contains the following groups :—

2. Senonian.
1. Pläner { Upper Pläner or Turonian. / Lower Pläner or Cenomanian.

1. Pläner.

Upper Pl. Turonian.	(*h.*) Cuvieri beds really Senonian. Marls and marly limestones with beds of green sand and conglomerate full of sharks' teeth : *Inoceramus Cuvieri, Ter. carnea, Ananchytes ovatus, Micraster cor-anguinum.*
	(*g.*) Scaphites beds with occasional flints. *Scaphites Geinitzi, Am. peramplus, Helioceras plicatilis, Inoceramus latus, cuneiformis.*
	(*f.*) White Brongniarti beds ; grey and snow-white limestone, compact and hard, or chalky. *Inoc. Brongniarti, Rhynch. Martini, Rh. Mantelliana, Ter. semiglobosa, Micraster cor-anguinum.*
	(*e.*) Red Brongniarti beds ; flesh-red marly limestone, hard and sometimes with conchoidal fracture : *In. Brongniarti, mytiloides, Rh. Martini, Mantelliana, T. semiglobosa.*
Lower Pl. Cenomanian.	(*d.*) Poor Rhotomagensis beds, fossils rare, grey-white solid limestones, hard, and with conchoidal fracture.
	(*c.*) Rhotomagensis beds, rock like *b. Am. rhotomagensis, Inoc. striatus, Plicatula inflata, Ter. biplicata, Holaster subglobosus, Discoidea cylindrica.*
	(*b.*) Varians beds. Hard grey limestones with marls, occasional grey-white massive limestones with earthy fracture. *Am. varians, Mantelli, Turrilites tuberculatus, Inoc. striatus, Plicatula inflata.*
	(*a.*) Green clayey sands and glauconitic marls. *A. varians, Mantelli, Mayorianus, Turril. tuberculatus, Inoc. striatus, Janira quinquecostata, Ostrea carinata, Rhynch. latissima, Hemiaster bufo, Discoidea subuculus.*

2. Senonian.

This highest division of the Cretaceous system extends uninterruptedly from Goslar to Ballenstedt in a great cake which spreads out northwards over the plain at the base of the mountains, and is not violently tilted up on end like the underlying strata, where they abut against the older rocks. v. Groddeck, to whose book I am principally indebted for the notice of the Harz rocks just given, states (p. 152) that the flat-lying Senonian rocks have been found in a railway cutting, through the Petersburg (to the E. of Goslar), to rest *unconformably* on the upturned edges of the Pläner, as is shown on Sections 3 and 4.

The western Senonian strata of this district are chiefly marls and limestone conglomerates, but towards the east along with these rocks a great series of sandstones comes on

—the so-called Quadersandstone—which forms the picturesque line of cliffs called the Teufelsmaner near Thale and Blankenburg.

The Senonian rocks have a rich fauna. A few of the principal species are *Siphonia punctata, S. ficus, Galerites elongatus, Ter. carnea, Janira quadricostata, Lima Hoperi, Spondylus striatus; Inoc. Cuvieri, digitatus, lobatus; Nautilus lævigatus, Belemnitella quadrata. Pentacrinites nodulosus; Ostrea flabelliformis; Exogyra auricularis; Cidaris clavigera; Holaster granulosus; Rhynch. ala, pisum.*

4. Tertiary and Pleistocene.

i. Oligocene.

The Eocene group is not represented in Germany, and the Brown coal, clay, and sand beds of the Oligocene series are everywhere found resting unconformably on the Upper Cretaceous rocks.

The Brown coal of Germany is principally of Oligocene age, but occurs at a few localities among the overlying Miocene strata. Patches of brown coal are found in hollows in the surface of the Secondary rocks around the Harz, *e.g.*, at Thale and Blankenburg, at Riestedt, near Eisleben, etc., and a small bed of brown coal has been found on the palæozoic rocks of the Lower Harz at Elbingerode.[1] The brown coals of the Harz are almost entirely composed of stems of *Taxites Ayckii* and *Taxoxylon Göpperti.*[2] The beds are very lenticular and generally of small superficial extent, but at some parts of Germany they reach a thickness of over 100 feet. They are associated with beds of fine clay, sand, and quartz pebbles. The latter are smooth and glossy, and have a well-marked individuality, so that they can always be recognised when associated with other rocks.

The Brown Coal of Germany was deposited in isolated lakes or ponds, and is not of terrestrial origin like most of the Carboniferous coal seams. It also differs from the palæozoic coals in being composed of wood and not of bark or

[1] Zeitsch. der deutsch. geol. Gesellschaft, xxix., p. 202.

[2] Credner, Elemente der Geologie, 4te Auflage, p. 643.

spores. In the Dorothea Mine at Clausthal, an ancient level was opened some years ago, in which the pine timbering, which had been imprisoned for about 400 years, was found converted into true brown coal, specimens of which may be seen in the Oberbergamts Museum there. The case is interesting, as it proves that under requisite conditions of pressure, warmth, and moisture, brown coal may be formed at a comparatively rapid rate.

k. Drift and Löss.

The Oligocene beds are covered by great sheets of drift (Diluvium) which extends over immense areas in the north of Germany, and consists of clays, sands, and gravels, of local or Scandinavian origin.

Erratics are abundant in the diluvium, and are found scattered over the western part of the Lower Harz, along with the so-called "Brown Coal Quartzite" pebbles. They have not been found on the eastern Harz; and the bounding line which crosses the range between Stolberg and Gernrode is taken as the western limit of the Great European ice cap during the period of maximum glaciation.[1]

Traces of glaciers are said to have been found in some of the valleys of the Harz.[2] Moraines have been described as occurring in the Oderthal, a deep glen which rises in the plateau between the Bruchberg and the Brocken at a height of 2500 ft., and runs southwards past Andreasberg to the border of the district at Lauterberg. The moraines are, however, far from distinct, and may ultimately turn out to be portions of old river terraces rounded off by subaërial erosion.

The much debated Löss occurs along the south-eastern flanks of the Harz near Nordhausen and on the Kyffhäuser near Kelbra. It is regarded by Dr J. Geikie as the flood loam laid down by the vast inundations that took place during the melting of the great glaciers.[3] The "Æolian

[1] See map of the Ice Sheet appended to Professor J. Geikie's recent Work, "Prehistoric Europe."

[2] E. Kayser, Verhandl. d. Gesellsch. f. Erdkunde Zu Berlin, 3 Decemb. 1881; also K. A. Lossen, Zeit. d. d. geol. Ges., xxxiii., 1881, p. 708.

[3] Great Ice Age, 2d edit., p. 550.

theory" of Von Richthofen may, however, be applicable also in cases where the Löss occurs at levels which rivers could hardly reach.

It is fine yellowish sandy or calcareous loam full of little twigs and rotten sticks. It is often totally unstratified, and bears very little resemblance to an aqueous deposit. Here and there stray pebbles and small patches of sand or gravel occur, and on a more careful search minute shells are to be found in abundance. These are terrestrial or lacustrine in character, and bespeak a moist soil and mild climate. Some of the chief species are *Succinea oblonga, Helix hispida, H. sericea, H. pulchella, Pupa muscorum, Achatina accicula.* Small marly concretions are found in the Löss which have often grotesque forms, and are named Lösskindel, Lössmännchen, etc. (löss babies, mannikins), by the German peasants, who see in them a fanciful resemblance to new-born representatives of genus homo.

The newest deposit is the alluvium, which is carried down from the Harz and spread in vast quantities along the banks of the rivers as they debouch on the plains, where, losing speed, they are obliged to relinquish the spoils they have plundered from the higher regions.

5. Massive Rocks of the Harz.

In noticing these rocks it will be most convenient to follow the order adopted by Lossen, and divide them according to their geological ages into the following groups:

a. Pregranitic Eruptive Rocks, .	Diabase, interbedded and intrusive; orthoclase porphyry; kersantite of Michaelstein.
b. Granitic and Related Do. do.,	Granite and granitite, amphibole granite, quartz and augite diorite, gabbro and enstatite rocks, kersantite of Lautenthal.
c. Postgranitic Do. do., ...	Quartz porphyry, orthoclase porphyry, porphyrite and basalt (melaphyre) of Ilfeld.

a. Pregranitic Eruptive Rocks.

Diabase.—This is the most widely distributed volcanic rock of the Harz, and occurs as interbedded and intrusive

sheets and bosses in the Devonian and Hercynian series, both on the Upper and Lower Harz. There are two varieties, one of which is compact and the other granular. The granular diabase, or diabase gabbro, as it is sometimes called, is a crystalline mixture of labradorite and augite or diallage with magnetite, titaniferous iron, and apatite, and is coloured green by a chloritic decomposition product. The fine-grained or compact variety has the same constituents, but is often characterised by the development of chlorite and calcite in spherules, when it is known as "Blatterstein." The plagioclase is occasionally porphyritically developed in crystals half an inch in length, when the rock passes into a diabase- or labradorite-porphyrite.

The diabase of the *stringocephalus* horizon, both on the Upper and Lower Harz, is associated with much pale green or bluish fine-grained tuff or schalstein. A very good section of the diabase and tuff beds of the Upper Harz is exposed in the bed of a small stream which runs into the Hutthal about 3½ kilos S.E. from Clausthal. The volcanic beds have also been cut through in making the road between Clausthal and Lerbach, but the section is now becoming rather obscured.

Orthoclase porphyry [1] or Syenite porphyry occurs, according to Lossen, as interbedded sheets along with the diabase of the Elbingerode basin. It has a fine-grained or compact ground-mass, with large crystals of felspar in Carlsbad twins, which has been ascertained to be of the variety named microperthite.

Kersantite [2] or Micadiorite was discovered by Lossen at Michaelstein a short distance westward from Blankenburg. Its relations to the surrounding rocks are obscure, but Lossen has placed it in the group of pregranitic eruptive rocks.

It is characterised by abundance of plates of biaxial mica not exceeding 1 or 2 mm. in diameter, and contains much orthoclase and plagioclase. Lossen considers the ground-mass to be orthoclase. Phlogopite, apatite, rutite, garnet, cyanite, sillimanite, and zirkon are accessory ingredients. The

[1] Lossen, Zeitschr. der deutsch. geol. Ges., Bd. xxxii., 1881, p. 175; xxxiv., 1882, p. 199.

[2] Lossen, Jahrb. d. k. preuss. Landesanstalt, 1880, p. 22.

kersantite of Michaelstein contains 54·25 per cent. of SiO_2 and 16·09 Al_2O_3.

b. Granitic and Related Eruptive Rocks.

More recently von Groddeck has described another occurrence of kersantite at Lautenthal on the Upper Harz.[1] The rock occurs here as a well-marked dyke, which runs southwards through the Culm greywackes from the edge of the Palæozoic series at a point a short distance westward from Langelsheim. It has a length of about 5½ miles (8 kilo.), and is continually shifted in a lateral direction by a series of faults so as to resemble on the map a flight of irregular steps. This kersantite has the peculiarity of having a percentage of silica, which varies between 46 and 63·6, and is nearly inversely proportional to quantity of carbonates contained in the rock. The fact of the dyke traversing the Culm strata, and being cut by the faults which intersect them, leads me to class it along with the members of the granitic group which bear the same relation to the surrounding rocks.

Granite occurs at three places as intrusive bosses—(1.) Brocken, (2.) Ramberg, (3.) between the Ockerthal and Radauthal, and at each locality is similar in composition. It consists of reddish orthoclase, greenish oligoclase, quartz, and black mica. White mica does not occur in the Brocken granite, and only sparingly at the other places. Tourmaline is found as an accessory ingredient in considerable quantities along with other minerals. The granite sends out veins or apophyses into the adjacent rock at many places. One of these runs from the granite of the Ramberg westwards through the Bodethal, and has been found by Lossen to possess a granitoid centre with porphyry sides, which show a true glassy base. The edges of the granite at Andreasberg and elsewhere show a passage into porphyry due to the more rapid cooling at the line of contact with the sedimentary rocks.

Amphibole granite, quartz diorite, augite diorite, etc., occur on the east side of the Brocken, at the edge of the granite near Schierke—the most inaccessible corner of the Harz.

[1] Jahrb. d. k. preus. Landesanstalt, 1882, p. 68.

Gabbro and *Plagioclase-enstatite* rocks are found in great masses between the granite of the Brocken and that of the Ockerthal. In the Radauthal above Harzburg, the gabbro is largely quarried for road metal. It is there made up of labradorite, hypersthene, and diallage, with titaniferous iron, magnetic pyrites, quartz, biotite, etc., as accessory constituents. Veins of graphic granite traverse the gabbro at places, and gabbro veins traverse the granite of the Eckerthal above Harzburg, showing both rocks to be contemporaneous.

Plagioclase-enstatite rocks occur in the gabbro in thin isolated zones, running from S.W. to N.E. They consist, when fresh, of anorthite, enstatite, and occasionally olivine, and can be arranged in a series, at one end of which the rock is made up almost entirely of anorthite, and at the other of enstatite. The olivine varieties have sometimes taken up water and become serpentinised, while the enstatite crystals remain entire, and give the rock a peculiar, semi-metallic, lustrous appearance. This variety of Schillerfels has been named *bastite,* from the Baste, a place in the forest, near the top of the Radauthal, where it is found in considerable quantity.

c. Postgranitic Eruptive Rocks.

Quartz-porphyry occurs in dykes and interbedded sheets in the Rothliegendes at Lauterberg. The dykes have a grey to reddish brown ground-mass enveloping large orthoclase, quartz, mica, and pinite crystals, while the sheets have few crystals, and weather in platey fragments like shales.

The quartz-porphyry of the Auerberg, near Stolberg, is a great "stock" or boss, with cream-coloured, grey, or greenish ground-mass, and abundance of quartz dihexahedra—the so-called Stolberg diamonds—which are very characteristic of the rock. Externally this rock resembles the quartz-porphyry from the coulée of South Corriegills, Arran, which is also full of double pyramids of quartz. The Arran rock is, however, much darker in colour than any of the Auerberg quartz-porphyry I have seen, and it shows fine flow-lines on weathered faces. The quartz-porphyry of the Auerberg shows signs of incomplete fusion with the sedimentary rocks

at the edges of the mass, and sends out several apophyses of felsite, which are of a yellowish brown tint, and to the naked eye almost undistinguishable from fine sandstone.

Orthoclase porphyry—the so-called grey porphyry of the Harz—occurs in a series of dykes crossing the Harz between Ilfeld and Wernigerode. It has for ingredients orthoclase, oligoclase, quartz, a dark green hornblende-like mineral, mica, and in lesser quantity, graphite, pinite, and garnets.

Basalt dykes run parallel with these, and are probably connected with the interbedded basalts of the Lower Permian group at Ilfeld.

The term *basalt* seems to me to be preferable to the old word *melaphyre*, which is in general use in Germany. There is really no petrographical difference between the two rocks, the term melaphyre being simply used as a synonym for basalt of Palæozoic age. To classify rocks on chronological grounds seems to be a false principle. Sandstone is surely sandstone, and limestone, limestone, whether it be Palæozoic or Pleistocene, and why should basalt not always be called basalt too, so long as it is really the same petrographical species? Speaking from the point of view of a geologist and not of a petrographer, I am of opinion that the name "melaphyre" should either, like the terms "trap" and "greenstone," be laid on the shelf or else be used in an altogether different sense, as its present signification can only be productive of uncertainty and ambiguity in geological investigation.[1]

Porphyrite occurs at Ilfeld in large interbedded sheets overlying the basalt of the Lower Permian series just described. It has a brown, reddish grey, or greenish groundmass, with decomposed porphyritic crystals of plagioclase and hornblende, and more rarely ironglance and garnet. The microscope shows the ground-mass to consist of orthoclase, plagioclase, a little hornblende, quartz, magnetite, apatite, and occasionally graphite and titaniferous iron.

[1] Compare Zirkel, Mik. Beschaff, p. 411; Rosenbusch, Mik. Phys. der massigen Gesteine, p. 392; A. Geikie, Text-book, p. 146.

6. Metamorphic Rocks.

a. Contact Metamorphism.

The granites and the intrusive diabases of the Lower Harz are surrounded by a fringe of more or less highly metamorphosed strata. The contact metamorphism has been carefully studied by various investigators, including Lossen, who has, at different times, given elaborate accounts of it in the "Zeitschrift der deutschen geologischen Gesellschaft." The compact diabases which generally occur in large beds are accompanied by "green shales" (grüne Schiefer), *i.e.*, micaceous chloritic shales with hematite scales, quartz, granular calcite, plagioclase, and siskin green epidote, either mixed with the rock or in strings and veins. The shales occur, as a rule, either above or below the Hauptkieselschiefer, but rarely in that rock itself. Ferruginous quartz, probably a decomposition product of the green chloritic mineral, and of the red ironstone to be afterwards noticed, occur along with the compact diabases.

The green shales are best developed in a band surrounding the diabase patches, between Stiege and Rodishayn, a village situated about 5 kilometers S.W. from Stolberg.

The contact rocks of the granular diabase gabbro are quite different from the green shales just described as occurring around the compact diabase. They are essentially divisible into two groups (1.) Kieselschiefer, (2.) "Band-" and "Fleckschiefer" or "Desmosit" and "Spilosit."

(1.) These siliceous shales really belong to a totally different family from the true kieselschiefer, whose acquaintance we have already made. They are intensely hard, have a flat conchoidal fracture, are very compact and splintery, and generally grey in colour, but are sometimes banded, and although very difficult to fuse, can, by a good blast, be converted into a whitish slaggy enamel. They have been classed as hälleflinta by Naumann, of whose nomenclature Lossen approves. The adinoles which occur at Lerbach on the Upper Harz are quite analogous to the hälleflintas—indeed, with the exception of the greater fusibility of the former, there appears to be no difference between them. The

adinoles at Lerbach occur between the Kieselschiefer in close proximity to the contemporaneous diabase and tuff beds intercalated with the Devonian and Culm at that locality.

(2.) The other facies of contact metamorphism is developed chiefly to the north of the central axis, while the variety just described occurs on the opposite side. It is characteristically developed on the river Lupbode below Allrode, and on the Rapbode between Rübeland and Hasselfelde, where the diabases are girdled by zones of "Spilosit" and "Desmosit." The former is a finely foliated schist with small spots of darker colour and undefined edges. The latter, instead of being spotted, has a banded structure, but is essentially the same rock.

The sedimentary rocks surrounding the granitic masses are much more highly metamorphosed. They are converted into hornfels—a comprehensive term, including a variety of rocks which have been hardened and altered into a tough horny mass. Heated water in trying to escape from before the rising mass of molten rock below, appears to have played an important part in the alteration of the sedimentary strata. The greywackes and clayslates contain an abnormal quantity of silica, and many foreign minerals, including garnets, actinolite, cordierite, mica, vesuvianite, and tourmaline, have, by the same agency, been formed in the altered rock. A schistose or gneissic structure is sometimes to be found close to the edge of the granite where metamorphism has been greatest.

b. Regional Metamorphism.

The Hercynian rocks, particularly those of the Wiederschiefer zone, have undergone a certain amount of regional metamorphism between the granite masses of the Brocken and Ramberg; and the Lower Devonian along a line running S.W. from the neighbourhood of Hettstedt, and parallel to the boundary of the Palæozoic series.

The metamorphism has, according to Lossen, been proportional to the amount of folding and contortion the strata have undergone. Between the granite masses a peculiar rock named *Porphyroid* is developed in considerable quantity. It

is a foliated rock with crystalline grains of quartz and felspar resembling felsite when the foliation is subordinate, and passing into sericite when the porphyroidal crystals are subordinate and the foliation predominant. The felspar is either orthoclase or albite. There are also semicrystalline sericitic greywackes, sericite schists, green ferruginous silicified shales, clayslates, and veins and geodes of amorphous quartz, with disseminated barytes, ironglance, and albite showing the characteristic triclinic striation. In addition to these minerals beds of shale containing crystals of karpholite occur in the S.E. metamorphic zone. The sericite is a compact mass of minute muscovite scales with usually a faint green colour, and bearing a strong resemblance to talc, from which, however, it can easily be distinguished by aid of the blowpipe.

7. Metalliferous Deposits of the Harz.[1]

a. Contemporaneous.

Devonian.—(1.) The famous copper and lead deposit of the Rammelsberg, near Goslar, has now been proved to be a set of great lenticular beds of ore in the Upper Devonian Goslar shale group, which is here inverted, and thus seems to underlie the Spirifer Sandstone which forms the top of the hill. The beds in which the deposit lies are inclined at a high angle, and it is not surprising that its true nature was for long an object of keen discussion. The fact that it is not a vein is proved in two ways.

1. The deposit is not symmetrically formed with regard to its hanging and foot walls as veins usually are, but consists of the following series :—

c. Fine-grained mixture of galena, zincblende, iron pyrites, and barytes next hanging wall.
b. Laminæ of pyrites and galena, "melirte Erze."
a. Copper and iron pyrites, with some arsenical pyrites resting on pyritous shale of foot wall.

2. There is perfect conformability between the rock and

[1] General descriptions of the various ore deposits of the Harz are given incidentally by von Groddeck in his admirable work, "Die Lehre von den Lagerstätten der Erze," Leipzig, 1879.

the ore, the latter partaking of all the crumplings the rock has undergone, and no evidence of a fault, fissure, or previously existing cavity, in which the ore could have been deposited, is to be found.

The Rammelsberg has a height above the sea of 2076 feet (633 m.), and is seen from Goslar as a bold rounded mountain mass which overlooks the plain from an altitude of about 1200 feet. The summit is clothed with pines, but the bare front of the hill is covered with long slopes of *débris* from the mouths of the shafts and levels inside. The lower half of the hill consists of the Goslar shale series which dips S.E. at 40° to 55°; higher up comes a thin bed of calceola shales which are covered by the Spirifer Sandstone, of which the top of the hill is composed. The ore deposit has been disclosed to a depth of nearly 1000 feet, and a longitudinal distance of 1400 yards. It sometimes reaches a thickness of about 65 feet, but at one place it sends off a bag-like branch produced apparently by the intense lateral pressure buckling together a part of the deposit, and here it has a breadth of 100 feet. (See Section No. 5.)

The copper ore of the Rammelsberg has been mined since the year 968 or 972, and was supposed to be nearly exhausted some years ago when a new portion of the deposit was found, which is now being vigorously worked. The old workings contain a great many secondary minerals, being formed from the decomposition of the pyrites.[1] These include (1.) Green Vitriol ($FeSO_4 + 7\ H_2O$) to which are related Botryogen, Roemerite, Voltaite, Misy (copeapite or coquimbite), Glockerite or Vitriolochre; (2.) Blue Vitriol ($CuSO_4 + 5\ H_2O$); (3.) White Vitriol ($ZnSO_4 + 7\ H_2O$); (4.) Gypsum ($CaSO_4 + 2\ H_2O$); (5.) Halotrichite or Haarsalz ($Al_2O_3\ 3\ SO_3 + 18\ H_2O$). When I visited the mine I was taken to a part of the old

[1] See different accounts of the Rammelsberg ore deposit, "Böhmer Bergm. Journ.," 1793; Reichetzer, Anl. zur Geogn. u. Gebirgsk, 1812, p. 264; Zimmermann, Das Harzgeb., I. Th., 1824, p. 318; Hausmann, Ueber die Bild. des Harzgeb., 1842, p. 133; Lossen, Zeit. d. d. geol. Ges., xxxviii., 1876, p. 777; Wimmer, Zeitsch. für Berg-, Hütten-, u. Salinien-Wesen, xxv., 1877, p. 119; Köhler, *Ibid.*, xxx., 1882, pp. 31 and 278.

workings coated over with stalactic crusts of these beautiful minerals, and was nearly stifled with the heat produced by the decomposition going on.

(2.) Red ironstone of Elbingerode. Between the diabase tuff and clayslates of the Middle Devonian rocks in the Elbingerode basin, there is a lenticular deposit of nearly 100 feet thick, and disclosed to a length of 4 kilos, consisting of siliceous and calcareous hæmatite (Fe_2O_3), spathic ironstone ($FeCO_3$), and some magnetic iron ore (Fe_3O_4). Another deposit of calcareous ironstone occurs entirely embedded in the tuff. It is mined chiefly at Lerbach, between Clausthal and Osterode. Red ironstone also occurs on the Upper Harz, along with the diabase and tuff on the same horizon. It is very siliceous at places, and occurs along with small quantities of spathic ironstone.

Permian.—(3.) The celebrated Kupferschiefer of Mansfeld has already been alluded to. It is simply a bituminous shale bed, with an average thickness of 18 inches, containing little particles of the following ores:—copper pyrites, erubescite, iron pyrites, galena, silverglance, zincblende, kupfernickel, and smaltine. The middle of the seam is by far the richest part, and has a peculiar appearance, which makes it easily recognisable by those who work it. The shale contains a fish fauna represented almost exclusively by the single species *Palæoniscus Freieslebeni. Platysomus* occurs rarely in this district. The seam is much faulted at places, and in the irregular fissures thus formed veins of various silver, copper, cobalt, and nickel ores are found, occasionally in workable quantity. These deposits are evidently derived from the solution of minerals in the seam.

The following analyses show the composition of the shale at different parts of the basin.[1]

[1] An elaborate account of the mines, statistics, and geology of the Mansfeld district was published in 1881, entitled, "Der Mansfeld Kupferschiefer Bergbau," from which these analyses are taken.

	Otto Shaft.[1] Right Wing.	Otto Shaft.[1] Left Wing.	Ernst[1] Shaft.	Glückhilf[2] Shaft.
SiO_2, . .	38·42	32·87	33·15	29·22
Al_2O_3, .	15·93	11·28	12·90	11·76
CaO, . .	10·93	14·31	14·39	12·66
MgO, . .	3·53	4·53	2·32	2·25
CO_2, . .	7·02	13·51	10·47	9·43
Fe, . .	1·81	0·85	3·31	2·97
Cu, . .	2·01	2·93	2·90	2·88
Ag, . .	0·015	0·010	0·016	0·021
S, . .	·18	3·96	2·15	4·97
Bitumen, .	14·63	14·07	9·89	17·21

Zn., Pb., Mn., Ni., & Co. not determined.

Jurassic.—(4.) At Harzburg four beds of fossiliferous oolitic brown ironstone (Fe_2O_3 H_2O) occur in the Ammonites Bucklandi beds of the Lower Lias, which is here inverted at an angle of 60°. They have an aggregate thickness of 13½ feet, and are mined for the ironworks of Harzburg.

b. Subsequent Deposits.

A. *In massive rocks.* (1.) At Zorge there are veins of hæmatite in the diabase which rarely pass out into the surrounding Kieselschiefer and greywacke. The ore is accompanied by quartz, brownspar, calcspar, etc., and is evidently derived from the surrounding rocks out of which the iron has been partially dissolved and redeposited in the fissures.

(2.) The Permian porphyrites of Ilfeld are traversed by small veins of Manganese ores—Manganite ($Mn_2O_3+H_2O$), Pyrolusite (MnO_2), Varvicite ($Mn_4O_7+H_2O$), Braunite (Mn_2O_3), Hausmannite (Mn_3O_4), Psilomelan and Wad. These are accompanied by barytes, calcite, brownspar (Ca. Mg. Fe.) CO_3, and occasionally manganese spar ($MnCO_3$). On passing downwards the veins become poor, and usually disappear at a depth of 5 or 6 fathoms.

B. *In stratified rocks.*[3]—(3). The great ore deposits of the Harz are the veins of Clausthal and St Andreasberg which have been mined for the last six centuries. The Clausthal

[1] Seen on section No. 1.

[2] 9½ Kilo. N.N.E. of Ernst.

[3] The Clausthal veins are described in detail by von Groddeck in "Zeit. d. d. geol. Ges.," vol. xviii., 1866, pp. 693-776; and xxix., 1877, p. 440; and those of St Andreasberg by H. Credner, vol. xvii., 1865, pp. 163-231.

mines have now reached a depth of 400 fathoms, and the ore shows no signs of disappearing. Those of St Andreasberg are, however, nearly exhausted, and although considerably deeper than the Clausthal workings there is little hope for their future productiveness.

The Clausthal veins contain argentiferous galena, blende, and copper pyrites, with spathic iron, calcspar, quartz and barytes as veinstones. Quartz and spathic iron occur in all the veins of the Clausthal plateau, but it is a curious fact that calcspar is only found in the area to the N.E. of the Innerste valley, while barytes is confined to the veins traversing the south-western and western portions of the district.

The veins are all in fault fissures which run E. and W. through the Culm strata, and usually hade to south. In some cases the downthrow exceeds 100 fathoms. The ore is distributed in the veins in various ways. It is usually in diagonal bands (Erzfälle), which slope towards the west, but occasionally occurs in columns or vertical ribs running parallel to the direction of hade. Besides the minerals just mentioned the veins contain smaller quantities of such minerals as dolomite or pearlspar, iron pyrites, marcasite, fahlerz or grey-copper, bournonite, heteromorphite, etc. The ores are usually richest where two of the larger veins meet and merge into one another. They sometimes reach a thickness of 130 ft., and generally contain a considerable quantity of fault breccia made up of fragments of the adjacent greywackes and shales. The foot wall is, as a rule, sharply defined from the vein, but the hanging wall is usually shattered and rough, so that the exact thickness of the vein cannot always be accurately stated.

The Andreasberg veins are almost all situated within an area resembling a very obtuse isosceles triangle with a base about 4 kilos in length. Two sides of the triangle are barren fault fissures (faule Ruscheln), full of fragments of clayslate and shale, with a southerly hade, and a breadth sometimes reaching 200 feet. None of the silver veins pass out of the area thus enclosed. All the outsiders are base, containing only copper pyrites and ironstone.

The silver veins are very thin, seldom exceeding half a yard in thickness. They run in two directions, speaking roughly. The first set consisting of several veins has an average strike of E. 60° S., and a steep hade to N.E., while the two veins of the second system run approximately E. 15° S., and hade to N. at an angle of 60° to 65°.

In the network of veins thus formed are found the many rare and valuable minerals for which Andreasberg has so long been famous. The silver veins are filled chiefly with turbid white calcspar containing grains, strings, and nests of quartz, and occasionally fluor, while splendid drusy cavities with crystallised calcite and zeolites are often disclosed. Galena, blende, native arsenic, ruby silver (Ag_3SbS_3), antimony, silver, arsenic silver, silverglance (Ag_2S), speisscobalt (smaltine), breithauptite (Ni Sb), and kupfernickel (Ni As), are some of the more valuable metallic minerals from the Andreasberg veins.

(4.) The great Devonian limestone boss of the Iberg and Winterberg at Grund is at places quite honeycombed with fissures and cavities, some of which contain spathic ironstone in workable quantities. The carbonate is often decomposed into brown ironstone, and is accompanied by quartz, calcite, barytes, malachite, and wad. Barytes is absent where the ironstone is richest. The limestone is also traversed by an argentiferous galena vein containing copper pyrites, spathic iron, calcspar, etc.

IV. GEOLOGICAL STRUCTURE AND HISTORY OF THE HARZ MOUNTAINS.

1. Older Palæozoic Period.

The Hercynian, Devonian, and Lower Carboniferous formations of the Harz form a continuous series, in which there are, so far as is known, no cases of unconformability to indicate any very great changes in the physical conditions under which they were deposited. The differences in texture show them to have been deposited in water of variable depth, but which never became very shallow till towards the end of the Culm period.

The oldest rocks are greywackes of moderately coarse grain, then come the clayslates, calcareous and siliceous beds of the Wiederschiefer group, which are covered by the sandstones and quartzites at the base of the Devonian series. Next comes a series of shales, greywackes, and occasional limestone beds, ending in the great Upper Devonian limestone mass of the Iberg and Winterberg at Grund. The overlying Culm measures begin with shales and pass into greywacke, the highest beds of which are very coarse and conglomeratic. There must thus have been a gradual shallowing of the sea and an approach to land in this area towards the close of the Lower Carboniferous age. The remains of land plants in the Culm tell the same tale, as they are found in greatest abundance in the higher beds but scarcely ever occur in the underlying shales.

The ancient land from which the components of the Culm are derived was probably a metamorphic clayslate area with many beds of splintery quartzite, and pierced by dykes and bosses of granite and quartz-porphyry, whose fragments now make up the conglomerate at the top of the series. In Silesia and sometimes in Thuringia the pebbles in the Culm greywackes can be traced to old rocks in the neighbourhood, but the parent rock of the Harz pebbles is neither to be found on older parts of the Harz itself nor in any of the surrounding ranges, nor are the pebbles ever again seen in the newer conglomerates which flank the hills. There must therefore have been a complete submergence of this part of the old continent during the Coal-measure period. It then became covered up, and has not again been exposed by denudation. The very same kinds of pebbles as are found in the conglomerate of Grund occur also in the Culm conglomerate of Waldeck, halfway between the Harz Mountains and Bonn on the Rhine, so that it is not improbable the shore of the sunken district may have extended westwards in that direction.[1]

2. Palæozoic Volcanic Action.

Lossen's map shows abundant patches of diabase distributed

[1] *Vide* v. Groddeck, Jahrb. d. k. pr. geol. Landesanst., 1882, pp. 65, 66; also E. Kayser, Neues Jahrb., 1884, footnote, p. 95.

over many parts of the Harz. Some of it is distinctly interbedded with the Devonian rocks, but it is equally certain that perhaps much more is intrusive, and hence of later date than the strata immediately surrounding it. There can, however, be little doubt that it is all older than the granite, and has either been poured out over the surface or injected into the underlying beds at some part of the Devonian or Lower Carboniferous period.

A. *Interbedded Diabases.*—Diabase of unmistakable subaërial origin occurs at two places on the Harz interstratified with Middle Devonian "Stringocephalus beds." (1.) It stretches in a long narrow band ("Diabaszug") from Osterode north-eastwards to Altenau, where it thins out and seems to disappear. It is here highly inclined, and, dipping to the south-east, rests on a thin band of Goslar shales, against which the Culm greywacke appears to have been brought down by a fault. (2.) The other interbedded diabase occupies a well defined area in the Elbingerode basin, about 13 kilos in length from east to west, and 5 kilos in breadth. Both volcanic rocks are associated with beds of tuff (Schalstein) and workable hæmatite, and are slaggy and amygdaloidal on their upper surfaces. The strata below these diabases are but slightly, if at all, altered, and there appears to be no sign of metamorphism in the fossiliferous shales and tuff beds between the different sheets.

B. *Intrusive Diabases.*—The other diabases are divided by Lossen into two classes—(1.) Diabase in the Hercynian and Lower Devonian formations, and (2.) that in the Goslar shales and Culm.

(1.) The diabase in the Hercynian beds of the Lower Harz occurs in a great multitude of patches of different size. The largest of these is at St Andreasberg, where it reaches a length of about 6½ kilos. The patches are generally, however, of small size, and occur in groups at particular places, *e.g.*, in the district to the north and east of Harzgerode, around Treseburg on the Bodethal, and in the district south of Wernigerode. At all these localities it is marked on the map as lying within the area of the Wiederschiefer, and indeed it is found so often in or near the same position that

the horizon has been named the "zone of the granular diabases." This fact might lead to the supposition that they are interbedded sheets, but the evidence seems to point to their having never reached the surface, but having been injected into the sedimentary strata either as stock-like bosses or else as sheets nearly coincident with the bedding planes. In this latter respect they may resemble the great Whin Sill of Northumberland, which was once believed to be a true interbedded rock because it remains for considerable distances in the same geological position.[1] A still better example might be cited in the great diabase sheet which extends from the East Neuk of Fife westwards through the Lomonds and Cleish Hills, then reappears in the Abbey Craig at Stirling, and continues on to Kilsyth, always remaining on the horizon of the Hurlet or "Carboniferous" Limestone. The distance between the east end of Fife and Kilsyth is over 50 miles—equal to the whole length of the Harz—and the Geological Survey have ascertained that the diabase throughout its whole extent is a distinctly intrusive sheet.

The facts which point to the intrusive character of these diabases are as follows:

1. *Want of Continuity.*—Had all the little spots of diabase been parts of great interbedded sheets they would have had a more or less continuous outcrop like the contemporaneous diabases of Elbingerode or the Upper Harz.

2. *Absence of Tuff.*—There is no tuff associated with any of these diabases as there is with the others, as well as with the Permian volcanic rocks at Ilfeld and Mansfeld. The absence of tuff—always a sure indication of subaërial origin—is, however, only of significant and not of vital import.

3. *Contact Metamorphism.*—The intense alteration in the sedimentary rocks surrounding most of these diabases is direct proof of their intrusive character. Lava streams produce in general very little alteration even on the beds over which they flow. Lyell tells of a lava stream on Etna

[1] See paper by Messrs Topley and Lebour "On the Intrusive Character of the Whin Sill of Northumberland" (Quart. Journ. Geol. Soc., vol. xxxiii., 1877, p. 406).

beneath which a mass of ice, instead of being melted, has been kept imprisoned by the overflowing molten mass; and a case has been observed in the coalfield of Borrowstounness[1] on the Forth, 18 miles west of Edinburgh, in which a coal seam, 9½ feet in thickness, was found in a perfectly unaltered condition between two sheets of contemporaneous carboniferous basalt, the overlying one having a thickness of 138 feet. The heat required to produce the contact metamorphism around the Harz diabases must have been much greater than that afforded by a contemporaneous lava, which would cool comparatively fast, and give off the greater part of its heat to the surrounding air or water. An intrusive rock would, on the other hand, remain hot for a very much longer period, and could only part with its heat through the surrounding rock, an equal quantity being given off on all sides. Some of the spots of diabase may be sections of necks or pipes up which molten matter continued to rise till it reached a height at which the superincumbent weight of rock was small enough to allow the diabase to spread out laterally in the form of a so-called "laccolite." The alteration produced around such a canal would necessarily be much greater than that in the neighbourhood of a simple dyke or stock, as the continuous welling up of molten matter would keep the temperature of the sides of the pipe at a great height till the current began to slacken and the diabase magma to solidify.

4. *Unconformability* of the diabase which is to be seen at many places also proves that the rock is intrusive and not contemporaneous. It is to be seen, for example, in the cutting at the side of the road leading down the west side of the Bodethal immediately below Treseburg. The clayslates in that section are completely cut across by the diabase, which has sometimes caught up portions of the sedimentary strata in a way which clearly establishes its intrusive character. The diabase at Mägdesprung on the Selke, N.N.W. of Harzgerode, is also discordant, but not in such a marked degree as at Treseburg. The contact metamorphism

[1] H. M. Cadell, The Volcanic Rocks of Borrowstounness Coalfield (Trans. Geol. Soc., Edinb., vol. iii., 1880).

has been very intense at that locality, and in addition to altered slates several new minerals, including actinolite and axinite, have been originated. Contact metamorphism is also developed around the granular diabase at St Andreasberg, and Credner's description of its geometrical relations as disclosed by mining distinctly shows it to be intrusive.

5. *A smooth contact surface* between the two rocks is of itself almost sufficient to establish the intrusive character of the diabase. A lava stream has rough and slaggy upper and under surfaces, and not smooth and sharply defined bounding planes like those seen at many places between the diabase and the sedimentary rocks. The mere conformability of a massive rock to the strata surrounding it is not necessarily a proof of its contemporaneity unless the upper and under edges be rough and scoriaceous like those of a true lava stream.

The same considerations apply generally to the diabases which abound among the Lower Devonian rocks in the southern parts of the Harz, and extend from Stiege, eastwards past Benneckenstein to the vicinity of Sachsa, and southwards to the border of the range near Rodishayn. There is here no tuff, the surrounding rocks are metamorphosed into the green shales described above, and what is still more conclusive, the diabase patches are shown on the map to cross from one horizon to another without regarding the strike of the sedimentary strata.

(2.) The diabase in the Goslar shales of the Upper Harz occurs chiefly in isolated patches on the hills between Goslar and the valley of the Innerste. It appears protruding through the soil at several places, and forms an oval cap to the Steinberg, a hill which overlooks Goslar from the west, and has a height of about 1450 ft. There can be little doubt that all the diabase in this district is also intrusive, as it does not conform to the strike of the shales, but rises irregularly through them. A fine section is exposed in a newly made cutting for a forest road along the western side of the Königsberg, which forms the south-western shoulder of the Steinberg. The section is at a bend in the road near the top of the hill, which commands a fine view over the wooded valley between

the Lutje Berg and the Nordberg. For a distance of about 100 yards, the shales which dip S.E. at about 30° are cut across and sometimes completely surrounded by the diabase, dykes and stock-like masses of which rise vertically or diagonally through them, sending out "apophysen" and hardening the strata at the contact edges.

The accompanying sketch section (Fig. 1) shows the relation of the diabase to the shales at one of the most characteristic parts of the exposure. Murchison and Sedgwick also give a section in which the diabase is seen rising vertically through the shales of the Nordberg. The shales are slightly inclined, and are here as on some parts of the Steinberg cleaved and converted into good roofing slates, which are largely quarried at different places round the base of the hills.

Another section of intrusive diabase is seen at the Teufels Ecke in the Innerste Valley below Lautenthal, at a point where the road has been cut into the Upper Devonian Kramenzelkalk beds to make room for the railway. The diabase is here very pyritous and weathers brown with a yellow efflorescence. It runs through the Devonian beds in veins whose presence can sometimes only be detected on careful inspection, as they are often not more than one or two inches in thickness. The whole section is about 20 yards in length.

The last case of intrusive diabase to be noticed is at the locality already referred to about 3½ kilos S.E. from Clausthal, where a good section of the overlying contemporaneous diabase is exposed in a stream entering the Hutthal. At the top of this tributary valley diabase veins are seen rising through the Goslar shales, which are here, as on the Königsberg, exposed in a small roadside cutting, and are inclined at a high angle. At some parts of the section the massive rock is in veins parallel to the bedding of the shales, but at others it is distinctly unconformable, and hardens the shales through which it passes. In all cases the edges are quite sharp, and not rough or slaggy.

It is probable that these diabases were irregularly injected into the underlying rocks, at the same time that the others

were being poured out over the surface as subaërial sheets, and, like the intrusive bosses and sheets of diabase piercing the Lower Carboniferous rocks round Edinburgh, they may fairly be considered to belong to the same period of volcanic activity as the interbedded masses above.[1]

3. First Upheaval of the Harz.

The rocks forming the core of the mountains were, as we have seen, deposited without upheavals or other interruption, from the basement of the Devonian to the top of the Culm measures. The area in which the Culm was deposited gradually approached the old coast-line and the water became shallow, but deposition was at last arrested by a vast disturbance which affected the whole region, and threw the newly formed rocks into a series of sharply folded troughs and arches.

The same disturbance appears to have folded the older rocks of the Rhenish provinces which strike in a similar direction, *i.e.*, N.E. or N.E. by E. This is the general strike of the rocks of the Upper Harz, which are most intensely folded to the east of Clausthal, but towards the west the undulations flatten out until between Seesen and Langelsheim the beds become nearly horizontal.

The strike of the Hercynian rocks of the Lower Harz is less uniform. These form, as shown on the map, an anticline which trends normally from Herzberg through the granite of the Brocken to Wernigerode. A second anticline extends from Lauterberg north-eastwards to Andreasberg, then swings round and runs eastwards past Hasselfelde to the neighbourhood of Harzgerode, where it bends northwards, and passes out of the palæozoic area at Gernrode.

4. Irruption of the Granite.

The great changes just described were followed by the

[1] I should not have gone into such detail over this point had there not been reason to suppose that some of the really intrusive diabases are regarded as being interbedded by several writers on the Harz. Kayser, *e.g.*, in his valuable and interesting paper on the system of faults around Andreasberg, asserts that the diabases of that district "are not dyke or stock-like masses but—like all Harz diabases—interbedded sheets [*eruptive Lager*]."

irruption of a huge mass of granite, *after* the rocks had received their present north-easterly strike, since there is no distinct evidence of the main features of the strike having been produced by this intrusion. The granite at some places cuts right across the upturned edges of the Culm and Devonian strata without producing any deviation in their trend.

The granite of the Brocken was regarded as the foundation of the geological series by the older geologists of the Wernerian school. When Murchison first visited the Harz in 1829 he was surprised to find, that instead of being the oldest, the granite was the latest of the core rocks through which it had been forced. He also subsequently reduced the so-called "Transition series" of the Harz to order, showing that much of the supposed very ancient greywacke was of no greater antiquity than the Culm measures of Devon, and that many of the slatey rocks belonged to the underlying formation which he had just named "Devonian."

5. Denudation of the Ancient Harz.

After the first upheaval, denudation began its work, and the products of erosion were carried away and deposited in the nearest sea bottom. Rolled pieces of the Hercynian rocks are found in the Coal-measure and Permian deposits on the flanks of the Harz, but why is granite, which has such a prominent place among the rocks of the Harz, conspicuous by its absence from these deposits? Was it perhaps injected at a much later date than that of the deposition of the border rocks? We shall see. The Upper Harz metallic veins are in large fault fissures which were formed after the rocks were folded. These veins run out to the edge of the old formations, and disappear under the Zechstein which rests unconformably on the core rocks, and also cuts off the veins abruptly, showing that the fissures were formed and subjected to atmospheric erosion before the Upper Permian period. Quartz-porphyry dykes are known to run through the core rocks in the neighbourhood of Lauterberg, and are probably connected with the interbedded quartz-porphyries of the Rothliegendes at that locality. They run sometimes along fissures parallel to these just referred to,

and as there is reason to suppose that all the fissures running parallel to the present edge of the Harz are of the same age, it follows that these fissures were in existence before the quartz-porphyries of the Rothliegendes period were erupted. The fissures must thus be of Carboniferous age, as they were formed between the great Upheaval and the Permian period.[1] They cross the Clausthal plateau from west to east, and although not known to be quite continuous, are represented by the system of fault veins which Kayser has traced across the Bruchberg to the Andreasberg district. These faults all cut through the granite wherever it comes in their way, and thus prove conclusively that it too is of Carboniferous age. The granite must have been quite hard and crystalline when the faulting took place, otherwise the fissures could not have remained open for the passage of metallic solutions.

The absence of granite fragments from the Carboniferous and Permian conglomerates is probably due to the fact that the granite masses at that time lay buried underneath sedimentary strata, and had not been exposed by denudation when the whole region became submerged.

Fragments of the Culm rocks are also unknown in the conglomerates of Ilfeld, but their absence is no proof that the Lower Harz was never covered by Lower Carboniferous rocks. The highest rocks would be carried off first and deposited in the deepest parts of the adjacent sea bed, and if Culm strata were present they would first be removed from this area. The eastern portion, if not the whole of the ancient Harz, must have remained above sea-level throughout the greater part of the Coal-measure period, during which the Culm may have been completely removed and laid down, perhaps at a great distance from the present base of the mountains. It is also possible that the Culm may not have been so thick in the eastern area as on the Upper Harz, and may have been eroded away comparatively soon, laying bare the underlying Devonian series, the greater part of which was also denuded off before the Permian period.

The preservation of the Culm of the Clausthal plateau is,

[1] E. Kayser, "Ueber die Quarzporphyre der Gegend von Lauterberg im Harz" (Jahrb. d. k. pr. Landesanst., 1880, p. 45).

no doubt, due to the great faults by which it has probably been thrown down below the plane of marine denudation. The Culm, Middle and Upper Devonian beds on the upthrow side, with an aggregate thickness of over 2500 ft., have at places been completely removed, laying bare the lowest part of the Devonian formation.

The intrusive diabases of the Lower Harz may have been connected with volcanic rocks interbedded with strata of Middle or Upper Devonian age at many other places besides Elbingerode. These would be also denuded away at this period, the Elbingerode beds alone being left, their synclinal position having helped to preserve them from subaërial erosion.

6. Newer Palæozoic Period.

The later phases of the great Palæozoic age were characterised by abundant volcanic action, accompanied by several physical changes of great magnitude, not only on the Harz, but over Britain and many other parts of Europe.

During the earlier part of the Permian period there were volcanos in both the Mansfeld and the Ilfeld districts, from which streams of basalt and showers of tuff were emitted. The basalt eruptions ceased after a time at both places, and the volcanic products were washed about by the waves and rearranged along the sea floor, or were covered up by sedimentary deposits. At Mansfeld there was not so much volcanic action during the remainder of the Rothliegendes period as at Ilfeld, where great sheets of porphyrite were poured forth, till they had reached a thickness of perhaps 1000 ft., and formed a bank extending upwards almost to the base of the Zechstein series.

A slight unconformability is sometimes found between the Coal-measures and Permian group, but at many places in the south-eastern parts of the Harz there is evidence of a marked geological break between the Rothliegendes and Zechstein formations. There is, at the Pfaffenthalskopf near Lauterberg, a patch of Rothliegendes, lying on the Hercynian rocks at a height of about 1600 ft., and consisting of red rocks interbedded with some of the quartz-porphyry before alluded to. At a lower part of the same area between the Pfaffenthals-

kopf and the border of the range, outliers of Zechstein are seen resting on the old rocks themselves without any red rocks between, which proves that the Permian strata had here been elevated and subjected to considerable erosion before the deposition of the Zechstein. The case in which the quartz-porphyry dykes run along lines of fissure in the Hercynian series has been already referred to. These dykes, as well as the fissures, are abruptly truncated by the Zechstein at several places, so that the interbedded volcanic rocks which were probably connected with the dykes must have been completely removed before the Zechstein began to form.

Hercynian pebbles occur in the Zechstein, proving that the Harz was not completely submerged at the close of the Rothliegendes period. During that long period of subaërial denudation the great series of red rocks at Mansfeld which sometimes exceeds 3000 ft. in thickness was deposited. It is, however, unlikely that the whole of the region now known as the Harz remained bare up to the Zechstein period, for it is probable that the eastern end of the area between Mansfeld and Ballenstedt was entirely covered by the red rocks, outliers of which have been left at Opperode near Ballenstedt and at Biesenrode near Mansfeld.

During the Rothliegendes period the Harz was surrounded by a ferruginous sea in which there was little life, but when the Zechstein age began an abundant fish fauna was introduced, and the fine mud which was being deposited all round the southern part of the district became mixed with particles of bituminous matter from the decomposing organisms in the water. Small quantities of metallic matter carried in suspension or solution were reduced and acted on by the hydrosulphuric acid and other gases evolved during the decomposition, and were deposited along with the bituminous matter and clay, chiefly as sulphides of the respective metals. The richest part of the shale contains about 3 per cent. of copper and $\frac{1}{100}$ per cent. of silver.

Now, the question suggests itself, where did these metals come from? Salt water and most felspars have been found to contain small quantities of the precious metals, and when felspathic rocks are eroded away their metallic ingredients

will be set free, and may, under requisite conditions, be precipitated as sulphides, oxides, or carbonates on the sea floor.

There is one contemporaneous metallic deposit still in existence among the palæozoic rocks at the Rammelsberg. It is also possible there may have been others now completely denuded away along with most of the Devonian rocks of the Lower Harz, and the Kupferschiefer of Mansfeld may perhaps be partly derived from their destruction. This is only a suggestion to account for the richness of the deposit at this locality. The seam extends over a very wide area, but is not valuable enough to work on the western flank of the Harz at Osterode, as it contains too little of the silver from which the profits are made. It is also found along the borders of the Thüringer Wald under the same conditions as on the Harz, so that over the great area between the two mountain chains there must have been a large inland basin in which deposition of fine sediment could go on in uninterrupted tranquillity.

7. Mesozoic Submergence.

The Zechstein is separated geologically by a wide gulf from the underlying Rothliegendes beds. The Upper Zechstein rocks bespeak a great change in the conditions of deposition around the Harz. The land gradually sank and became completely submerged, as no more pebbles of Palæozoic rocks are found in any of the overlying formations from the Kupferschiefer upwards to the Chalk.

The conditions during the Mesozoic ages appear to have been generally tranquil in this region, and the various formations to have been laid down in large open areas in which marine forms could thrive and produce limestones and fossiliferous shales and marls without disturbance by upheavals or volcanic eruptions.

There can be little doubt that the Harz was covered by the whole of the Secondary formations up to perhaps the middle of the Cretaceous system, as these are found, both on the northern and on the southern borders of the range. The Cretaceous series, so abundant along the northern Harz border,

does not occur in the immediate neighbourhood of the southern flanks, but is found in a few outliers on the Ohmgebirge about 20 kilometres S. of Herzberg, which proves that it once extended for a certain distance between the Harz and Thüringer Wald. The southern region has been elevated more than the northern, and consequently denudation has there proceeded more rapidly, and has succeeded in carrying off nearly all the Cretaceous and a large part of the Triassic formations.

8. Final Upheaval of the Harz and Kyffhäuser.

a. The Great Faults.

The Mesozoic formations of the plain are abruptly cut off from the Palæozoic core rocks by an irregular line extending along the northern border of the range from Langelsheim to Ballenstedt. The edges of the newer rocks are in many places turned up, curled back, and inverted at an angle of 60° or 70°, thus appearing to dip beneath the Palæozoic series.

That there is along this line a great fault is proved by the following evidence:—

1. *The abruptness of the line of contact* and steep inclination with which the core rocks plunge down through the Secondary formations of the plain. Had there been only an unconformability the Palæozoic series would have sloped gradually away below the overlapping Secondary rocks as along the southern Harz border.

2. *Concealment of the lowest beds.*—The Zechstein occurs as a thin band between Ballenstedt and Ilsenburg at the very edge of the core rocks, in the usual inverted position; but farther west, between Harzburg and Langelsheim, it is concealed or "nipped out," and the old rocks are bounded by the overlying Bunter sandstone. There is good reason to suppose that the Zechstein is present here, and had there been an unconformability like that along the southern edge of the Harz it would have been clearly exposed.

3. *Intersection of Different Horizons.*—The old rocks cut across the strike of the Secondary formations from Zechstein to Cretaceous, which can only be explained by a fault.

4. *Inversion of Strata.*—This is a most convincing piece of evidence in favour of a powerful fault. A similar inversion occurs along the fault which has tilted up the Edge Coals on the west side of the Midlothian Coalfield. An effective sketch of such an inversion is given in Geikie's "Text-book," fig. 252.[1]

5. *Brine springs* occurring at the edge of the Palæozoic rocks at Harzburg show that there is a fissure communicating with the great salt bed known to exist below the Triassic rocks of the plain.

A similar fault appears to bound the northern edge of the Kyffhäuser. The gneiss on which the red Permian beds forming the top of the hill are seen to rest has apparently been brought up against the Zechstein and Trias in the way indicated on the accompanying section (No. 2). Neither of these faults seems to have been noticed by previous observers, as no indication of their presence is given on any geological map which I have seen.

The great fault of the Harz appears to run out and disappear towards Langelsheim on the west. The unconformability of the Coal-measures and Permian beds upon the upthrow side of the fault near Ballenstedt (shown on section No. 1) resembles the unconformability of the Old Red Sandstone on the northern side of the great Caledonian fault between Crieff and Cortachy in Forfarshire.

The horizontal platform of Devonian rocks on which the newer Palæozoic rocks at Ballenstedt rest is seen to be nearly on a level with the flat lying Upper Cretaceous beds of the adjoining plain. The amount of upthrow of the fault at this locality is thus equal to the thickness of the border rocks from the base of the Rothliegendes to the middle of the Cretaceous series. The red Permian rocks of Mansfeld reach at places a thickness of 3300 feet, but it is probable that only a part of the series, which may be taken at 1000 feet, extended over this portion of the Lower Harz. The thickness of the Secondary formations is variable, especially if the vast triassic salt deposits be taken into account. It is 3000 or 4000 feet along the northern Harz

[1] See also A. Geikie's "Field Geology," chap. x.

border, but to avoid exaggeration let us say 2000 feet. The great fault must therefore have produced at this locality a relative vertical displacement of no less than 3000 feet —an amount probably much smaller than that of the upthrow in the neighbourhood of Blankenburg, Wernigerode, or Ilsenburg, where the maximum effect would be produced.

b. Character of the Upheaval.

The upheaval which gave birth to the Harz, as we now know it, thus took place very simply. During the earth movements which affected Europe at the close of the Secondary period, a great corrugation of this part of the earth's crust took place along lines running approximately W.N.W. and E.S.E., as shown by the trend of the Harz, Thüringer Wald, and other ranges, and by the flexures of the Mesozoic strata in the plains between them.

The final upheaval of the Harz was a process of quiet elevation of the area *en masse*, and quite different in character from the first upheaval in the Carboniferous period. The metallic veins formed before the emergence of the modern Harz appear to have remained undisturbed during the upheaval, and there is no evidence of any folding or relative shifting of the core rocks having accompanied it. The last upheaving force here acted in a direction nearly at right angles to that of the first, and was less violent in the local folding it produced, but was felt over a much larger párt of the European area.

In the region now known as the Harz a great swelling up of the earth's crust took place. A line of weakness running along the northern side of the district gave local relief to the pressure from below, and allowed the whole area to rise like a huge trap door on a level stage, hinged at the south, and free to open upwards on the north. The Mesozoic rocks on the south side of the dislocation would be quietly elevated on the back of the Palæozoic mass beneath. On the north side they remained stationary or sank downwards, but were bent up and curled backwards along the line of fracture by a pressure like that produced by a great wedge driven upwards from below.

A fault, however powerful, could scarcely have produced an inversion to the extent of 60°. It seems probable that the fault only tilted the beds on end, and pushing them slightly over the vertical, left gravitation to finish the inversion by causing them to sink backwards on themselves till they came to rest at their present inclination. The inversion is not always so regular as the accompanying sections indicate. In an excavation to the W. of Goslar, where material for a railway embankment was being excavated in Sept. 1882, the marls and limestone beds of the Kenper and Muschelkalk were seen bent sharply over thus <, the beds represented by the upper limb of the figure dipping in towards the Harz at 40° to 60°, and those below dipping away from the mountains at 50°. This sharp inversion may have been produced by the falling back of the beds in the way indicated. The inverted marls were at places much crushed and contorted.

Murchison was inclined to consider the granite as the upheaving agent, but from what has been said it will be evident that the granite and the upheaval can have had no immediate connection.

9. Denudation and Age of the Modern Harz.

A. *Denudation.*—The fact that no traces of the Mesozoic rocks are to be found on the Harz is no proof whatever that they did not once completely cover that area. The upheaval began before the end of the Cretaceous period, and from the time of the Eocene period onwards the Harz has been under the action of subaërial denudation. We have in Scotland abundant evidence of vast denudation since the Miocene period. The country has received its present configuration, the valleys have been scooped out, and a thickness of at least 2000 feet must have been removed from many exposed districts since the great basalt eruptions of the Hebrides ceased. The rocks of the Highland area so removed are chiefly hard quartzites, grits, slates, and schists of various kinds, as well as the massive basalt beds, all of which would offer a far greater resistance to the eroding forces than the limestones, marls, clays, and sands of the Mesozoic series. If, then, the

denudation of the Scottish Highlands has been so great since the *Miocene* period, how much greater must have been the denudation of the Harz since the end of the *Cretaceous* period. There has been abundance of time for the removal, not only of the Secondary formations which covered most of the Harz to a depth of perhaps 2000 or 3000 feet, but also of some of the underlying core rocks. The granite of the Brocken was not laid bare when the final submergence took place as we have seen, and its present exposure is due to the last denudation subsequent to the removal of the Mesozoic covering.

The fact of the Senonian rocks resting unconformably on the upturned edges of the Turonian and underlying Jurassic and Triassic rocks near Goslar, as shown on section No. 3, proves that the final upheaval began before the end of the Cretaceous period. The inversion must have accompanied the first stage of upheaval, and if the sections are correctly interpreted there must have been a period during which the upturned and shattered strata were laid bare and exposed to subaërial denudation before the Senonian beds were deposited. Evidence of the upheaval and denudation of Precretaceous Secondary rocks exists at other parts of Germany. At Peine, in Hanover, for example, there is at the base of the Senonian series a great deposit of limonite pebbles containing Liassic fossils.[1] Precisely similar pebbles occur in the Neocomian "Hils conglomerate" along the northern border of the Harz, which points to a disturbance having occurred so early as the beginning of the Cretaceous period at this locality. The Senonian series contains, in addition to limestones and marls, limestone conglomerates in the district between Harzburg and Langelsheim, while towards the east a great development of sandstone takes place. Although no Jurassic fossils have, to my knowledge, been found in the Senonian group at either district, it seems possible that these fragmental beds may be partly derived from the waste of the Secondary formations in course of slow elevation along the southern side of the dislocation. The upheaval may have gone on locally and irregularly at first, but seems not to have been great enough to raise the Palæozoic rocks above

[1] See von Groddeck, "Erzlagerstättenlehre," pp. 265, 266.

sea-level till the end of the Senonian period, when the *whole* sea floor was laid bare, and all further deposition arrested.

There appears to be no evidence of post-cretaceous submergence in this district, and it is difficult to determine the date at which the upheaval ceased. The most important representative of the Tertiary deposits is the Oligocene Brown Coal which occurs in depressions at various places on and around the Harz. A bed of workable brown coal, 50 feet in thickness, occupies a bay-like hollow in the core rocks immediately adjoining the line of fault at Wienrode between Thale and Blankenburg. The coal appears to cross the line of dislocation, and rest on the upturned edges of the Zechstein and Red Bunter sandstone in a way which seems clearly to show that the upward movement had entirely ceased before the agencies of denudation had hollowed out the depression subsequently filled up by the vegetable deposit.

10. Recapitulation.

The area now occupied by the Harz Mountains was, during the Palæozoic period, a portion of the great sea in which the Silurian, Devonian, and Lower Carboniferous rocks of Central Europe were deposited. The alternating greywackes, sandstones, shales, and limestones, with their accompanying fossils, indicate changes in the depth and condition of the water, but form throughout a perfectly conformable series. Volcanic action was vigorous in the Devonian period, when diabases and tuffs were emitted at various parts of the area.

Towards the close of the Lower Carboniferous period the sea shallowed, and deposition was finally arrested by the upheaval of the new-made rocks which were thrown into a series of violent folds, with a general N.E. and S.W. trend. The folding was followed by the irruption of great bosses of granite, after which the region was dislocated by a series of powerful faults which produced the fissures now filled by the metallic veins of the Upper Harz. The faulting took place at the time of the Upper Coal Measures, and the upheaved area remained exposed to subaërial denudation throughout the remainder of the Carboniferous period. The

products of erosion were deposited in the adjacent sea, and are found in the Coal-measure and Lower Permian conglomerates which overlap the borders of the range. Volcanic action was rife, and basalts, porphyrites, and quartz-porphyries were erupted along the southern flanks of the district, while the old palæozoic core was invaded by dykes emanating from the volcanic centres.

The volcanos became extinct, and submergence began at the end of the Lower Permian period. The highest of the shore conglomerates underlies the Kupferschiefer seam of Mansfeld, which was deposited at the beginning of the Zechstein period, in a great inland lake extending from the Harz southwards to the base of the Thüringer Wald in Saxony. The area remained submerged below the sea in which the Triassic, Jurassic, and Cretaceous formations of the surrounding plain were being laid down.

Signs of earth movement began to appear during the Cretaceous period. The sea-bed was thrown into undulations with an E.S.E. and W.N.W. trend, and the Mesozoic rocks were rent along one of the waves by a great fault, on the southern side of which the rock mass of the Harz was upheaved to its present altitude. A seam of brown coal crosses the line of fault at one locality, proving the movement to have ceased before the Oligocene period.

The Harz has not again been submerged, but was probably partially covered by a portion of the great European ice-sheet during the period of maximum glaciation. The Secondary formations, under which it was deeply buried when the upheaval took place, have long ago been swept off by the action of the subaërial denudation to which the Harz has been unceasingly exposed since the end of the far-off Cretaceous Age.

V. APPENDIX.

A. Literature.

The literature on the geology of the Harz is very extensive, and it is impossible to do more than notice some of the more important works and papers here. A tolerably complete list

may be found in von Groddeck's "Abriss der Geognosie des Harzes," and several of the less important papers have already been referred to in footnotes.

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B. EXPLANATION OF PLATES.

The Sketch Map, Plate IX., is intended to indicate roughly the general structure of the Harz, and to show the positions of most of the places referred to in the text, and of the lines of Section in Plate X. The contemporaneous diabases are shown, but the numerous patches of intrusive diabase, as well as the dykes of quartz-porphyry, etc., have, to avoid needless complexity, been omitted.

The Sections, Plate X., are drawn to the same scale as Lossen's Map. The verticals are about double the horizontal distances. The sections do not pretend to any great accuracy in detail, and are intended merely to serve as illustrative diagrams approximately correct in general outline only.

Section No. 1 shows the unconformable patch of newer palæozoic rock near Ballenstedt on the south side of the great fault, and the position of the Mansfeld basin at the S. E. extremity of the range.

No. 2 shows the general structure of the Lower Harz and Kyffhäuser.

No. 3 indicates the probable unconformability in the Secondary series at Wernigerode, the relations of the rocks in the Elbingerode district, and the position of the Permian volcanic masses at Ilfeld.

No. 4 shows the unconformability below the upper chalk on the north side of the great fault, the relation of the granite of the Brocken to the faults, the position of the silver veins of Andreasberg, and the relations of the Permian rocks on the southern flank of the Harz.

No. 5 illustrates the structure of the portion of the West Harz between Goslar and Seesen The great inversion of the Rammelsberg is shown on the east, and the Culm greywackes and shales are seen overlying the Upper Devonian beds on the western side of the Innerste Valley. The Kersantite dyke of Lautenthal is seen piercing the Culm, and altered in position by one of the faults.

XIX. *On the Classification of Animals.* By J. Cossar Ewart, Esq., M.D., Regius Professor of Natural History in the University of Edinburgh.

(Read 20th February 1884.)

Until comparatively recent years naturalists chiefly concerned themselves with drawing up definitions of animals, and with elaborating systems of classification. The arrangement usually adopted was extremely unnatural, for the systematists trusted either to external characters or to very simple combinations of characters. In course of time, however, great advances were made—the internal structures were taken into consideration, so that when a new era was introduced by the appearance of the "Origin of Species" in 1859 an almost perfect natural system of classification had been devised, and it seemed as if the theory of descent with modifications had been unconsciously used in making the arrangements, "and not some unknown plan of creation, or the enunciation of general propositions, and the mere putting together and separating objects more or less alike." Until the time of Cuvier naturalists were bent upon establishing one continual uniform series to embrace all animals between the links of which it was supposed there were no unequal intervals. But even after Cuvier's time the old traditions

were adhered to. Lamarck, who stumbled upon the theory of evolution, but was unable to marshal a sufficient array of facts to support it, still seems to have believed in the possibility of arranging animals in a linear series, and, it may be added, that at the present day this old notion has been saddled to the theory of descent by those who have not been carefully initiated into the mysteries of biology. The possibility of arranging animals in a linear series is, however, no longer admitted by naturalists—they know that the relations animals have to each other cannot be represented on a plane surface, but only in space of three dimensions; that in fact the only possible method of classifying animals is to arrange them in divergent groups and redivergent sub-groups, or, in other words, to represent them in the form of a tree. Further, various groups, *e.g.*, orders, families, genera, and species, are no longer looked upon as being always equivalent, but rather as arbitrary divisions adopted for convenience, and not because they have the same comparative value. If a natural system of classification is founded on descent with modifications, it must be strictly genealogical in order to be natural, hence the various groups (orders, families, genera, etc.) must be considered as expressing the amount of difference amongst organisms which have descended from a common ancestor, and which together form a branch or phylum; and it may be added, that the possibility of dividing groups into orders, genera, etc., has resulted from members of these groups undergoing elaboration and differentiation in different directions. This being so, the particular rank which any number of individuals receives will depend partly on the amount of elaboration and partly on the disappearance of the immediate or remote ancestral forms, or of both.

From what has been said, it will be evident that in drawing up a system of classification it is necessary to distinguish adaptive from essential characters, and to remember that no arrangement can be natural that is not genealogical. The safest characters therefore will be those that show an affinity between organisms to each other or to an ancestral form. When arranging animals into large groups, we should therefore notice especially the developmental history. This, however,

is not enough in the case of vertebrates, *e.g.*, it will be necessary further to take into consideration the most fixed structures—the skeleton and nervous system, the generative organs, the heart and respiratory organs, and any rudimentary or atrophied organs that may be present. When breaking up the large groups into sub-groups, it will be necessary to direct attention to the amount of elaboration that has taken place, or to the specialisation any series of organs has undergone, or to the appearance of new organs.

Although the system of classification at present generally in use is to all intents and purposes a natural system, and although it does not fail to recognise in a general way the genealogical affinities, it must be admitted that it is at the best a most disjointed system, and that the definitions are often drawn up in such a way that they seem to apply equally well to several distinct forms or groups. How then might the present arrangement be improved? How can the relationships be better expressed and the definitions made more definite? A system of classification ought to enumerate all the information we possess about the various groups and individuals composing them. This was the case with the systems of Linnæus and of Cuvier. Since their time, however, we have not only collected an enormous number of facts as to the structure of animals, but we have learned much of their distribution, development, and ancestral history. Hence a classification now must not only express all we know as to the structure, but also all we know as to the ontogeny and phylogeny of the organisms considered. The most suggestive and useful classification ought naturally to assume the form of a genealogical tree, and the definitions, instead of merely enunciating what are supposed to be the ordinal generic and specific characters, ought to express as far as possible the relationship indicated by this tree—to interpret or explain these relationships, and at the same time suggest the amount of elaboration and specialisation, or it may be the amount of degeneration that has taken place. Our knowledge of extinct forms is not yet sufficient to enable us to follow out this ideal system; but it may be possible, without waiting until geologists fill up the many gaps, to

improve somewhat our present mode of drawing up definitions, if not of classifying. Those acquainted with such works as Gunther's "Classification of Fishes" must know that the various groups are usually considered as if they included independent and specially created forms, and no attempt other than grouping allied forms together is made, either to indicate their relationship or the amount of elaboration or specialisation that has taken place. Further it must have been observed that Haeckel and others have long recognised the necessity of a change in our mode of classifying and defining organisms, and especially of adopting a simpler and more philosophical plan than has hitherto been followed, so that in venturing to indicate on what lines our classifications might in future be conducted, I am only following the example of other naturalists.

The system which I would recommend will be best illustrated by taking a familiar group as an example. I know of no group that will serve better for this than the fish group. In the Fishes I would, at the outset, draw up a short definition containing only absolute characters, and, as far as possible, characters which would not only suggest, but in a great degree be applicable to the ancestral forms. This short statement made, each order would next be dealt with separately. Before giving any definitions I would enumerate all the genera of the order, showing in as graphic a manner as is possible how, on a flat surface, these might be arranged into sub-families, families, and suborders or other groups. This done, I would next draw up a short definition of the order, containing, as in the definition of the class, only absolute characters. If two or more suborders, I would select the one which seemed to approach nearest to the ancestral forms and draw up an exhaustive statement of its characters; in other words, I would describe in a categorical fashion a typical member of the group.

Having done this I would next indicate as shortly as possible how the members of this particular family differed from the type described, either by being more elaborated or specialised, or by having undergone degradation. When necessary, in addition to showing the relation of each genus

to the selected type, I would discuss separately each genus, showing how one species differed from another, and how they were related to their own particular genus, just as we might compare the leaves belonging to a particular twig, and indicate how they were individually attached. The genera and species having been considered, I would conclude with a definition of the family, never using vague terms, such as "usually" or "generally," and always mentioning the exceptions in detail.

Having treated all the families of the suborder in this way, I would next compare the various families with each other, indicating how they essentially differed from each other, and how they had departed from what were supposed to be the ancestral forms. All the other suborders would be treated in the same way, with this difference, that whenever it was possible, instead of giving an exhaustive statement of the characters of the type selected, I would simply show how it differed from the original type which served to illustrate the first suborder. When all the suborders had been considered in this way, I would next compare the various suborders, indicating, when possible, along what routes they had severally travelled from their starting point—what amount of elaboration they had undergone—how much they had been specialised or degraded—whether they were at or near their climax, or approaching their decline—what amount of parallelism there was amongst them, and in what respects they chiefly differed—also, how their present compared with their past distribution—and how far they or their ancestors had been traced into previous epochs.

XX. *Note on "Deserted Spawning Grounds of the Herring."*

BY J. COSSAR EWART, Esq., M.D.

(Read 19th March 1884.)

Certain inshore banks around the British coast, and along the shores of Norway and Sweden have long been frequented by the herring when about to spawn. Some of these banks have been visited, chiefly in the autumn, while others have

been visited in the spring. One of the best known banks visited in the autumn is the Guillam Bank, near to the entrance to the Cromarty Firth, while the bank off Ballantrae is the most familiar resort during the spring. In addition to these there are many others well known to our fishermen. The famous Bohuslan spawning ground on the coast of Sweden is noteworthy. All these spawning grounds are liable to be deserted for longer or shorter periods, *e.g.*, the Guillam Bank has practically been deserted during the last fifteen years; the bank off Dunbar has been deserted for a still longer period; the Ballantrae Bank was all but deserted for several years; while the herring shoals left the Bohuslan grounds in 1808, and did not make their appearance again in any numbers until 1877. The disappearance of the herring has been accounted for in an endless number of ways, but we are still without definite information on the subject, and likely to continue in this condition until we learn something more of the causes which influence the movements of the herring, either in search of food or in selecting spawning grounds.

An important step in this direction would be accomplished in determining whether herring, like salmon, are in the habit of returning to their birthplace during the spawning period. This might be done by depositing on some of the deserted in-shore banks large quantities of fertilised eggs. If, in the following year, after the spawn had been deposited, these banks were frequented by numbers of young herring, and during the second year with a school of spawning herring, it might be taken for granted that they were the products of the eggs deposited. Supposing this to be the result, a number of interesting problems would be, to a great extent, settled, and an extremely practical conclusion arrived at, viz., — that when spawning beds have been deserted, instead of waiting until some accident brought a new school of herrings, some twenty, thirty, or fifty years hence, it would be possible to treat them as so many farms, restocking them when necessary, so as to restore the fishing. Having been deeply impressed when examining the Ballantrae spawning grounds with the desirability of some such course as this being

pursued, I took into consideration how it could best be carried out. In stocking rivers with trout and salmon, good results are often obtained by depositing eyed-ova in either natural or artificial redds. The advantages of depositing eyed-ova over newly fertilised ova are (1.) that the water in the redds often contains a quantity of mud, which, though harmless to the fry, is fatal to the eggs during the early stages of their development; (2.) that owing to the variations in the temperature of the water passing over the redds, the embryos when hatched are often so feeble that they are incapable of surviving; (3.) that owing to the protection afforded during the earlier stages, the number of fry hatched is likely to be greater.

In the case of the herring there is practically no risk from impurities in the water, and the number of ova obtained from each female herring being so great the destruction of a considerable number by fish, etc., is not a matter of any moment, and this destruction is limited compared with the salmon, as they are often hatched in ten or twelve days, and are seldom over forty days in hatching. Hence, all that is required is, that a sufficient number of fertilised eggs should be deposited on the spawning ground. At first it seemed that this would be easily accomplished by dropping stones, etc., coated with eggs on the bank, but on finding that the eggs were apt to be destroyed when this was done, and that the gravel-coated portions of the bank were always selected by the herring in preference to others, I devised a simple apparatus for conveying the egg-coated stones safely to their destination. This apparatus is in the form of a galvanised iron tray about 20 inches in diameter and about 4 inches in depth, with a bottom consisting of two portions hinged to a central bar so as to open outwards. This tray is provided with four cords, two attached to the rim and one to each half of the false bottom. When loaded with stones which may be coated with eggs on both sides, the tray is deposited, all the four cords being held tight until it reaches the bottom. On reaching the surface of the bank the cords attached to the false bottom are set free, while the other cords are drawn up, the result being that the two halves of the bottom open outwards leaving all the

contents of the tray on the bank. In this way many millions of eggs could be easily deposited in either shallow or deep water.

Specimens Exhibited.

February, 1884.—Professor Ewart exhibited a specimen of *Torpedo nobiliana*, taken by a trawl in 40 fathoms water off Lybster on the 11th of January. The specimen measured 28 inches in length, and 19½ inches across the pectoral fins, and was 13 pounds in weight. It was of a uniform dark chocolate colour on the upper surface, while the under surface was nearly white. Though several torpedoes have, in all probability, been captured off the Scottish coast, this seems to be the first that has been identified and preserved. It has been presented by the Scottish Fishery Board to the Museum of Science and Art. A figure of this specimen will be found in the Annual Report of the Fishery Board for Scotland for the year 1883.

March 19*th*. — Professor Ewart exhibited the following specimens: (1.) *Raniceps trifurcus* (Tadpole fish), taken in the Firth of Forth; (2.) *Physis blenniodes*, the Great Fork-Beard; (3.) *Gadus minutus*, the Power Cod, taken off Eyemouth; (4.) an albino Haddock (*Gadus æglefinus*) from Stonehaven; (5.) a Coronula taken from the "Tay Whale" (*Megaptera longimana*); (6.) stones coated with eggs of herring, dredged from the Ballantrae Bank on the 8th of March; and (7.) living Herring fry which escaped from the eggs on the stones on the 16th March.

PROCEEDINGS

OF THE

ROYAL PHYSICAL SOCIETY.

SESSION CXIV.

Wednesday, 19th November 1884.—RAMSAY H. TRAQUAIR, Esq., M.D., F.R.S., President, in the Chair.

The CHAIRMAN delivered the following opening address:

GENTLEMEN,—We come together this evening in the full hope and confidence that the success and prosperity which have attended our gatherings during the past few years will not be less in the present Session of the Royal Physical Society, the 114th since its foundation. On this occasion I think we may justly point to the new part of our *Proceedings* now on the table, and containing the papers of last session, as evidence that our prosperity is not merely one of increased membership, or of gathering in of fees, but of work done. For the first time in my memory the *Proceedings* of a previous session have been laid on the table ready for distribution on the opening night of the following one, and for this we must thank the energy and industry of our Secretary, whose position as Editor of these *Proceedings* is by no means one of calm contemplation, but one of hard and often very harassing work. The part itself consists of 273 pages, with 10 plates, and contains 20 papers besides an address by Dr A. Geikie, Director-General of the Geological Survey. In this address Dr Geikie gives, in his well-known lucid style, an admirable

exposition of the present state of knowledge regarding the growth and origin of coral-reefs, and of the manner in which our faith in the Darwinian theory of these structures has become gradually shaken and undermined by the progress of subsequent research.

Except that they include no contributions from the chemical members, the 20 original papers well represent the various branches of scientific work which it is the special function of this Society to encourage and prosecute. Eleven of these deal with subjects in recent zoology: of these five are ornithological—those of Mr Swinburne on the Birds of Sula Sgeir or North Barra and North Rona; of Mr Dalgleish on a Second Collection of Birds and Eggs from Central Uruguay; and two papers by Mr Harvie-Brown, and one on the Occurrence of the Little Gull.

It is only natural that Ornithology should be, as it always has been, prominent in the matters brought before our meetings, seeing the wide general interest which the subject evokes, and the opportunities afforded by Scotland for observations connected with this department.

Two papers record researches in Invertebrate Anatomy, one of these being the beautifully illustrated and carefully worked-out paper of Professor Herdman on *Sarcodictyon*, the other an interesting note by Mr Beddard on the Structure of the Body-Wall of certain Earthworms. We must regret that we have lost the advantage of Mr Beddard's presence amongst us as a resident member, but at the same time we must congratulate him on his well-deserved promotion to so important a post as the Prosectorship to the Zoological Society of London.

Two papers relate to distributional marine zoology; one by Dr J. R. Henderson on Shells and Zoophytes from the Firth of Forth not previously recorded in the Society's *Proceedings*—a very appropriate paper for our Society, being supplementary to the valuable list already published in our *Proceedings* by Messrs Leslie and Herdman. The second is a Revised List of British Ophiuroidea by Mr Hoyle, of great importance to those interested in the geographical distribution of our marine invertebrates. What a difference there is

in this subject since the publication of Forbes' "British Starfishes"!

We are also glad to see that the Professor of Natural History in the University is taking an active part in the business of the Society, and, besides exhibiting at our meetings many fishes of interest, including the first Torpedo caught off the Scottish coasts, has furnished this number of the *Proceedings* with two papers. The first of them, on the Classification of Animals, embodies the modern theory of descent in relation to this subject; the second, on Deserted Spawning-grounds of the Herring, deals with important economic matters, which he has recently taken up as a special study, and which must command the interest of a much wider circle of readers than those who busy themselves with the details of Comparative Anatomy or of Systematic Zoology.

The remaining nine papers, nearly half of the whole, are upon subjects which the popular mind usually, if not quite accurately, associates under the general notion of "Geology," and are indeed of the kind generally considered to be proper subjects for Geological Societies. And here I must congratulate the Society on the good appearance which the present number of the *Proceedings* has made in this direction, which shows that we are not neglecting our function as a Geological Society, handed down to us from the days of Fleming and Hugh Miller. I would also urge the Society assiduously to persevere in cultivating Geology and Palæontology, and in doing so I think it a matter of congratulation that so many members of H.M. Geological Survey favour us with their attendance at our meetings and their contributions to our *Proceedings.*

Three of these papers deal with physical or pure Geology, namely, on Boulder-Glaciation by Mr Hugh Miller—on the Breadalbane Mines by Messrs Wilson and Cadell—on the Harz Mountains by Mr Cadell. One paper relates to the mineralogy of the silver districts of Colorado by Mr H. Gunn. The other five are palæontological—of which three are on Fossil Botany—two by Mr Kidston, and one by Mr Theodore Richards,—while two are on Fossil Ichthyology by myself.

Last June I had the pleasure of attending an interesting

meeting in the new Natural History Museum at South Kensington, brought together for the purpose of discussing certain interesting questions connected with zoological nomenclature, to which I will refer further on. At present I may quote one sentence from the introductory remarks of Professor Flower, who presided,—"I have often had little difficulty in making out the characters and structure of an animal, and even the functions of some of its organs, but when I have to decide by what name to call it, I am often landed in a sea of perplexity."

Certain it is that the correct naming of animals and plants is one of the most serious difficulties with which museum officials, and investigators generally, have to contend. Well do conservators of museums, where scientific assistance or access to books is deficient or inadequate, know the difference in value between an authentically-named collection and one which is not.

I fear, however, that to the outside laity, who have never approached the study of Natural History from a scientific point of view, and who imagine, as I know many do, that the only work of a museum curator is to put his stuffed birds and beasts on shelves, and see that they are not corrupted by dust or moths, it must be a perfect mystery what all this talk about nomenclature means. Such persons often wonder why naturalists choose to becloud and encumber the science, which they profess to love, by what are popularly termed "jawbreaking" names—for their part they are quite content to go on speaking or writing about "*the* spider-crab," or "*the* white butterfly," or "*the* wild goose," or "*the* dogfish." Just the other day a letter appeared in the *Scotsman* newspaper, expressing immense contempt for the ignorance of the Firth of Forth fishermen in believing that *the Dogfish* brought forth its young alive. A discussion in the correspondence column ensued, in which it was shown that there were many kinds of small sharks known as "Dogfish" round our coasts, and that though some of these deposited eggs, others, and notably those most likely to be known to our local fishermen, actually are viviparous.

Here, however, some one more enlightened as to diversity

and as far as possible to remedy the evils already created by it, a committee was appointed by the British Association for the Advancement of Science in 1842; and the report of this committee, drawn up by the late Mr Strickland, was published in the *Proceedings* of the Association for that year. In 1865 these rules were amended by the Association, under the reportership of Sir W. Jardine.

The rules and recommendations comprised in that report have received pretty general adoption in this country, and must be well known to all naturalists who have made much progress with their studies. Like the binomial system itself, I must maintain that they have worked well, and for the benefit of science. But they have not been in every particular followed by naturalists abroad, and even in this country we often hear ominous notes of dissent as to their sufficiency for the wants of the science of the present day.

They must, however, form the basis for all subsequent attempts to rectify the subject, and consequently I shall adopt them as the text for most of the few remarks with which I have to occupy your attention this evening.

To enter into every intricacy connected with the subject would, in a short address like this, be not only impossible, but also unsuited for the occasion. I must therefore content myself with touching on a few important points, concerning which there seems at present to be some difference of opinion.

The British Association Rules wisely commence by recognising that a scientific name is only a name like any other, and not a condensed diagnosis or description, and that consequently inexorable adherence to priority in generic and specific names is the only safe and effectual rule. Even names whose derivation was founded on mistaken ideas of structure cannot be altered upon that ground, if their title is otherwise good. M'Coy, for instance, named a genus of fossil Brachiopoda "*Athyris*" (without a door), in the belief that no foramen existed in the beak, but though it subsequently turned out that a foramen was present, the name *Athyris* must nevertheless stand.

The claim of names to priority does not extend, however,

find the Turbot designated in Willoughby's "Historia Piscium," published in 1686. These were, indeed, not names in the proper sense, but condensed diagnoses. It is, as we all know, to Linnæus that we owe what is known as the Binomial system, according to which each kind of organism receives two names, the first of which—the generic name—is that of a genus or assemblage of kinds of animals or plants closely resembling each other, while the individual species is particularised by the second or specific name—as, for instance, *Pleuronectes maximus*, the Turbot; *Pleuronectes platessa*, the Plaice.

The shortness and convenience of the binomial system ensured its universal adoption, but the want of agreement among naturalists as to definite rules for working it out, and their frequent ignorance of each other's works, contributed towards a considerable amount of failure on the part of the system to secure accuracy or universality. Synonymy, or the fact of one species having a plurality of names applied to it by different authors, grew apace, and became, as it is to this day, a nuisance. Some amount of synonymy cannot under any conditions be avoided; it is indeed conditioned by the progress of science, which often renders necessary the sub-division of old and too extensive genera, and the rectification of both genera and species. But that synonymy should be allowed to extend itself indefinitely and heedless of all rule or principle, constituted indeed an obstacle in the way of accurate scientific work. Ignorance or disregard of books published in another country might indeed be expected at a period when the intercourse between different nations was very much more restricted than it is now, and in times, too, when naturalists felt less than they do now that they form a brotherhood united by ties independent of political nationality; but on what principle, it might be asked, did writers sometimes change also the specific names of organisms when they thought proper to transfer them to other genera? and other instances might be given of the arbitrary way in which names given by one writer were dealt with by others coming after him.

To endeavour to check the growth of unnecessary synonymy,

and as far as possible to remedy the evils already created by it, a committee was appointed by the British Association for the Advancement of Science in 1842; and the report of this committee, drawn up by the late Mr Strickland, was published in the *Proceedings* of the Association for that year. In 1865 these rules were amended by the Association, under the reportership of Sir W. Jardine.

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to those which are Pre-Linnæan, and the 12th edition of the "Systema Natura," published in 1766, in which the binomial system was perfected, is chosen as the limit. It is true that there is some dispute concerning this matter, with which we are, however, not vitally concerned at present.

On the whole, the desirability of strict adherence to priority seems to be very generally admitted, though now and again we do meet with instances of disregard to this rule in cases where there is really no need for uncertainty as to its application.[1]

The whole principle has, however, so far as specific names are concerned, been recently boldly attacked by Mr Seebohm, who, in the introduction to his "History of British Birds," maintains that the specific name to be adopted is not necessarily that which was first proposed, but that which has been oftenest used. Mr Seebohm's names are all *auctorum plurimorum*, and, "under this system, no new names can possibly be raked up and applied."

It is impossible not to feel some amount of sympathy with those who feel unwilling to cast aside a widely-known name because an older one has been "raked up," or who find, in the adoption of the *plurimorum auctorum* principle, the readiest solution of all the disputes as to the identity of species imperfectly or erroneously described by older writers. But surely it is now time that ornithologists and other specialists had arrived at some conclusions as to which of the names given by those old writers, have thorough claims to validity;—if not, I am not yet convinced that it is Utopian to hope for such a consummation. In any case I am convinced that if we lose our hold on the law of priority, we shall find ourselves plunged into dangers far more serious

[1] For instance, Professor Miall of Leeds, in his work on "Sirenoids," published by the Palæontographical Society in 1878, proposes to unite a number of forms of *Ceratodus* described as distinct species by Agassiz (*Ceratodus altus, emarginatus, dædalius*, etc.) into one. Now, in such a case, one of Agassiz's names, the first according to strict rule, clearly has priority over any which Mr Miall could devise; but, nevertheless, on the inadmissible ground that Agassiz's names are "too descriptive," he cancels the whole of them, and proposes the new one *polymorphus*. This name simply cannot be recognised.

than the trouble occasionally arising from the restoration of old names, which ought in reality never to have been lost sight of.

But what is necessary to secure priority? Not merely the giving of a name to a specimen in a collection, nor even the publication of such a name, unless there be also published a description which is sufficiently intelligible and definite to enable the specialist who is conversant with the particular group to identify the form in question. Some would also require a figure to be given, but I must demur to that being an essential condition. No doubt a figure is a great aid to certainty, but so in a much higher degree is the ocular inspection of the type, which must often be resorted to when even figures fail. But MS. names, and names published without descriptions or figures, have no right to priority whatever. Though it is indeed a graceful act for an author to recognise and adopt MS. names when he has the opportunity of describing the specimens to which they have been applied, they cannot possibly stand in cases where other names have been already given by authors independently, and published with descriptions.*

The next question is—what constitutes publication? And here I fear that some confusion, or at least difference of opinion, exists in the minds of many people. The rules of the British Association demand that the description shall be inserted in a printed book, and here I fully agree, with the addition that the printed book ought also to be had for sale. Many people hold that priority may date from the reading of a paper at a scientific meeting, even though it might not have been published for months afterwards. Well, that may do very well as far as the general credit of scientific discovery is concerned, but the priority of a name is not a matter of credit, but of rule. Even as regards credit, the thing is not satisfactory. Could we ensure that all scientific

* This principle does not seem to have been understood, certainly not accepted, by Mr J. W. Davis in writing his recent work on the fishes of the Carboniferous Limestone, in which he insists on restoring, on the plea of "priority," the mere MS. name *Cladacanthus paradoxus* of Agassiz which had been quite legally superseded by the name *Erismacanthus Jonesii* given by M'Coy.

societies throughout the world would insist on the paper being delivered complete to the secretary before it is read, and would forbid all subsequent alterations and additions, something might be said on behalf of this view. But in the case of only too many societies, the author may retain his MS. for weeks, often for months after the nominal reading,—sometimes only a few words of extemporary explanation,—has taken place, during which time he is at liberty to cook it as he chooses. It may be said that we must assume all men of science to be likewise men of honour, but names may be inserted into a paper between its reading and publication, without any intentional design to rob others of their right of priority, though that might indeed often be the consequence if priority were suffered to date from the nominal time of reading.

Before leaving the subject of priority I must allude to the practice of altering an old specific name when that name has been elevated to the rank of a generic one. For example, *Cyprinus carassius* of Linnæus, the Prussian carp, received afterwards the name of *Carassius vulgaris* (Willson), the authority of Linnæus for the species being consequently altogether lost. The rules nevertheless in 1842 authorise such a change, on the ground of the inelegance of such a combination as *Carassius carassius*, but it seems to me that the inelegance is of much less importance than the unwarrantable interference with the law of priority involved by the substitution of another specific name, such as *vulgaris*. It is much to be regretted that any such elevation of specific into generic names was ever allowed to take place; and in justice to the British Association committee, it must be noted that in 1842 they strongly discountenanced the continuation of the practice. And in the revision of 1865, it is proposed in such cases to retain or replace the old specific names and to change the generic ones.

The Committee of the British Association, after framing rules for the rectification of previous names, proceeds to give a series of recommendations to be followed as a guide for the future. Some of these call for no special comment on the present occasion; others do. I think we must all agree

with recommendation *i*, which deprecates the propounding of names of "harsh and inelegant pronunciation." The outside public are too ready to denounce as "jawbreakers" even really elegant names of classical origin; how they can relish such terms as *Enaliolimnosaurus crocodilicephaloides*, which the committee quote as an example, may be imagined! And that the making up of such cacophonic names is by no means a thing of the past, any one may convince himself by looking into some of the biological literature constantly issuing from the press. Our poet laureate, Lord Tennyson, in portraying the feelings of a person contemplating a lovely shell which he has picked up on the sea shore, makes him say:

> "What is it? a learned man
> Could give it a clumsy name.
> Let him name it who can,
> The beauty would be the same."

Scientific names are indeed not given to organisms with the object that they may fit into lines of poetry, or indeed be used in non-scientific writing at all; but at the same time it is not desirable that they should be of such a form as to outrage the susceptibilities of those who happen to possess musical ears.

But I am not so sure that I can equally well agree with them in their denunciation of what they call "nonsense names," that is, "names coined at random," without any derivation whatever, such as *Assiminia*, or *Spisula*, or anagrams of other generic names such as *Dacelo* from *Alcedo*. Most writers who have occasion to propose new genera, know by sad experience the difficulty of making up names for them from their Greek dictionaries, and how that when one has fixed upon some salient feature demanding the institution of the genus, and compounded a nice euphonious name to express it, one is pretty sure to find, on testing it by reference to the "Nomenclator," that it is long ago preoccupied by some beetle or bee, or something of that sort. In fact so enormous is the number of genera already proposed, that unless we consent to the repetition of the same name in different divisions of the Animal or Vegetable Kingdoms, the difficulty of

devising names not preoccupied is immense. If, then, a person with a good musical ear invents a nicely sounding word of classical form, surely it is as good as some cacophonous "jawbreaker," whatever be its derivation. Here my feeling is that a name is a name, and nothing else.

Another rule or recommendation in the first set of rules of 1842, to which I must take exception, though after all the matter is not one of very vital importance, is that all specific names whatever, even if derived from persons or places, must be written with a small initial letter. I thoroughly fail to appreciate the use or advantage of this, even for the reasons given by the committee, and it does look very ridiculous to an eye accustomed to proper names being spelt with a capital in all European languages, to meet with such a form as *Aphrocallistes bocagei,* after Professor Bocage. Although by the revision of 1865, this rule ceased to be binding, we find it still extensively adhered to by naturalists in this country.

We now approach a subject of great importance, regarding which the greatest difference of opinion and practice exists among naturalists, that is, regarding the name of the author to be placed as "authority" after the double name of a plant or animal. Although it has been remarked that it was a "Pandora's box let loose upon science," when the practice of appending the authority to a name was introduced, yet the reason for doing it is perfectly obvious. If the object of scientific nomenclature is to secure accuracy and precision, then we must also record the author who gave the name, that in case of any uncertainty or dispute we may refer back to his description. Here there would be no difficulty were it not that the progress of science, as already mentioned, so often requires subdivision and rectification of old genera. *Trichecus rosmarus,* the walrus, is *T. rosmarus Linnæus,* and will remain so,—Linnæus being responsible both for the species *rosmarus* and its combination with *Trichecus.* But when a species originally described under one genus is put under another genus by a subsequent writer, the question arises as to whose name is to be appended as authority—that of the original describer of the species or of the author of the new combination? The plan used by older writers

was in all cases to quote the author of the combination only, whether he was the original describer of the species or not, and this method is still used by many naturalists, including, I understand, all botanists. But the plan adopted by the British Association committee was in all cases to quote only the name of the author of the species; where, however, the species had been removed to another genus, to add the letters "sp." to show that his responsibility stopped with the species. The reasons given are—1st, that to quote the then authority for the new combination alone is to rob the author of the species of his due credit; 2d, that "by giving the authority for the specific name in preference to all others, the inquirer is referred directly to the original description, and is at the same time reminded of the date of its discovery, habitat, etc., of the species, while genera being less numerous than species, may be carried in the memory or referred to in systematic works, without the necessity of perpetually quoting their authorities." Professor Alexander Agassiz, in his introductory remarks to the Revision of the Echini, takes exception to the "credit" view of the case, and says that the author of the combination is quoted simply to show that in his works the placing of the species under the genus will be found, and that in the table of synonyms, which he will probably give, the reference to the original description will be found. And our friends the botanists declare that to call a plant *Semele androgyna*, Linnæus, is an untruth, because that was not the name given to it by Linnæus, who on the contrary called it *Ruscus androgynus.*

I must agree with Professor A. Agassiz so far that the question of "credit" should not be entertained, and I consider that its introduction by the Committee of the British Association was a mistake. Though it may be very right that an author should get due credit for what he has done for science, yet the quotation of the authority for a name is not a matter of credit, but of precision and convenience. Nevertheless, I must emphatically take the side of the Committee in the plan which they proposed, and which has met with approval from a large body of naturalists, especially in Great Britain.

To my mind the real and essential name of an animal or plant is its specific one, which ought by no means to be called a "trivial" name as was done by Linnæus, and the generic name is simply one added to show its close relationship to allied forms as well as its distinction from other species which may possess the same name. We might also add the name of the family, order, and so on, but this would occupy too great a space, and is rendered unnecessary by the law which forbids the use of generic names already preoccupied.

It is true that this view of the case is somewhat obscured by the fact that generic names are always substantive, while specific ones are usually either adjective or in the genitive case, which gives an appearance as if the real and fundamental name of the organism were the generic one, and the specific one merely added to designate a variety. This is, however, a purely conventional arrangement, which does not affect the true nature of the case, which is clearly evident when we consider that the name of the species is by the rule of priority unalterable, while the combination is not subject to any such law. Hence, in testing the accuracy of any identification, it is fundamentally necessary to go back to the original description of the species, all subsequent generic combinations being merely expressions of the opinions of individual authors as to the position and classification of the organism in question. Accordingly, considering that the specific name is in fact *the proper name* of each organism, I must fully agree with the committee of the British Association, that the authority for *it* should be quoted in preference to all others; though, as is also recommended, it is desirable, when the genus has been subsequently altered, to indicate this by adding the letters "sp.," or by placing the authority in brackets.

Furthermore, I consider that the citation of the author of the species gives the expression a historical value which otherwise it would not have if every author who chose to subdivide an old genus is at liberty to put his own signature after the new combinations he has produced.

A sort of compromise has been recommended, and has

been frequently used—I see Mr Hoyle adopts it in his "Catalogue of British *Ophiuroidea*," which has just appeared in our *Proceedings*—namely, that of writing the authority for the combination immediately after the specific name, and besides that appending the name within brackets of the original describer of the species. The principal objection which I have to this plan is, that I consider it cumbrous and really unnecessary.

Though there are many of us who are still quite content with the good old Linnæan plan of having two names for every organism, there are others who are not quite satisfied with two, but in some cases would like three, if not four. Hence the discussion on "trinomial nomenclature" which took place in the Natural History Museum in London in June last, to which I have already referred.

Now, there are two kinds of trinomialism. The first works by the institution of *subgenera.* When the species of a large genus can be arranged in subordinate groups, *subgeneric* titles are instituted for these; and each of the species, except those of the typical subdivision, comes to have three names—the first generic, the second subgeneric in parenthesis, and the third specific.

To this I feel quite averse, as being an unnecessary interference with the shortness, conciseness, and convenience of the binomial system. If the groups in question are sufficiently distinct from each other—well, that is a case for subdivision, reserving the old generic name for the typical group, and instituting new genera for the others, as I myself felt constrained to do with the genus *Palæoniscus* of Agassiz. But if they are not, I see no adequate reason for complicating our good old system by sticking in a third name in brackets, though in systematic works or catalogues the species under any genus may be grouped in any way the author pleases, provided the type species comes first.

This form of trinomialism was alluded to at the meeting at the British Museum by Dr Woodward, and defended by him on the ground that the thorough breaking up of the old genera, such as *Ammonites,* into new ones, increased the labour of the student, who was already hampered with too

many names; and so the insertion of a third name, which might not be insisted on as a matter of instruction, was convenient. Having had a little experience both of being examined and of examining in turn, I can cordially sympathise with the student, preparing for his trials, in any complaint of "overpressure." But the question of how far he is to master the details of nomenclature, or how many scientific names he is to cram up, seems to me to be one for the teachers and examiners rather than for the working scientists. From my own experience, I rather fear that the ordinary student is more oppressed by the recent advances in comparative anatomy and embryology than by the number of generic names which he has to learn.

But the trinomial system chiefly discussed at the meeting referred to is not connected with "subgenera," but with "subspecies." Bearing in mind the only practicable definition of a species, namely, a form which has not yet been positively shown to intergraduate with any other—(if we are evolutionists, we believe that the connecting links have been lost; if we are not, we believe they have never existed)—it has long been a recognised fact that under these species subordinate forms or "subspecies" occur, often distinct enough when extreme forms are compared, but passing into each other when a well-selected series is put under observation. These "subspecies" belong to quite a different category from accidental varieties or sports, being characteristic of geographical regions where they breed true, and in very many instances have been named, described, and long considered as true species. They are, in fact, in the eye of the evolutionist, species between which the links have not been lost.

That these are facts, and that their expression is not provided for in a strictly binomial nomenclature, is acknowledged by every one; the question comes to be, *how* best to give them expression? Hitherto the usual solution of the difficulty, without interfering with the integrity of the binomial system, has been to give subspecific or varietal names, and to append them to the proper name of the species, the word "variety," contracted "var.," being inter-

posed. Another way has been long ago proposed and used by some naturalists, and has lately been brought into considerable prominence by ornithologists in America, especially by Dr Coues, the eminent author of the "Key to the North American Birds." This plan consists in omitting the term "var.," the subspecific term being simply added, so as to become an integral part of the name of the organism, which accordingly becomes trinomial, or composed of three words.

Dr Günther, for instance, in his "Catalogue of Fishes," uses the expression *Salmo fario gaimardi* to designate the variety of the common trout characteristic of Scotland and the northern parts of Europe, while that of England and the central parts of Europe he calls *Salmo fario ausonii.*

Example of birds, from the beginning of Coues' new "Check list" of North American birds:

Turdus migratorius, Linn.—The Robin.
" " *propinquus*, Ridgway — Rocky Mountain Robin.
" " *confinis* (Baird), Coues—St Lucas Robin.

Of course there are two primary objections to this plan, namely, that there must be a considerable amount of arbitrariness in selecting particular varieties or subspecific forms, as requiring or worthy of a third authoritative name; and secondly, that, having fixed upon these, the transitional forms are left out of account. To meet the latter objection, Mr Seebohm proposed a supplementary plan of his own, amounting, in fact, to a quadrinomial system. That is to say, in order to indicate and include the intermediate links between two subspecific forms, he would append to the name of the species two subspecific names joined by a hyphen.

E.g., *Cinclus aquaticus* melanogaster (Scandinavia).
" " *melanogaster*-albicollis (W. and Central Europe).
" " albicollis (S. Spain, Algiers, Italy, Greece).
" " *albicollis*-cashmiriensis.
" " leucogaster (E. Siberia).

E.g., *Cinclus aquaticus leucogaster*-cashmiriensis (Central Siberia).
" " cashmiriensis (Cashmere, S. Siberia and Mongolia).
" " *cashmiriensis*-sordidus (Altai).
" " sordidus (Thibet).

Well—I hardly think that the time has yet come for any radical interference with the binomial system, which has worked so well from the time of Linnæus to our own, notwithstanding all its defects. No doubt if the doctrine of descent be true, and if we had the whole genealogy of living and extinct forms before us, all definition of species, genera, families, and so on, would be absolutely impossible; not merely the binomial system would be found insufficient, but also the trinomial and even Mr Seebohm's four names would fail to effect their purpose. It is in fact the imperfection of the record which enables us to give names at all, and naturally our difficulties increase the more the progress of research among recent and fossil forms brings to light a little more of the record previously unknown to us.

The use of generic and specific names will, however, I fear be long, indeed, not merely practicable, but necessary, and meanwhile I think it will be much better for us to keep to the binomial system, and to limit the authoritative names to forms which, so far as we can judge, are "good species," dealing with sub-species according to the usual plan of inserting contractions for the terms variety or sub-species.

I quite understand the scope and limits of the trinomial system as advocated by Dr Coues, but I very much fear that if such a system were to receive the authoritative sanction of naturalists these limits would not be observed by the crowd of name manufacturers. The great objection to introducing such a plan at present is its certainty of abuse by incompetent and inexperienced observers, and especially by that class of writers whose sole function in life seems to be to invent new names on the most trifling pretext. "If," as I observed at the meeting, "the binomial system is at present often abused by such people for the creation of species which *have* no existence save in their own imaginations, what

might we not expect them to do if the adoption of a trinomial system afforded them further scope for their faculties?" If the system could be brought into palæontology, what might we not expect of people who make new species upon broken fish teeth? They would rush at the new system with hungry avidity, and the results might not conduce to the progress of science.

Before concluding these somewhat rambling remarks on Nomenclature, I would desire to say a few words on a somewhat interesting subject, namely, the attempt sometimes made to substitute vernacular names for Latin ones in systematic Biology. Here I shall content myself with our own language, and the subject as it occasionally manifests itself in English books.

Some excellent and well-meaning writers, who are of course well aware of the necessity of scientific names, nevertheless seem to be persuaded that these names act in deterring ordinary people from the study of Natural History. Perfectly aware also that the mass of organisms known to science never had English names, and that the names of such as have them are from want of precision useless in scientific work, they set themselves to work out systems of English names, which, aiming at the same sort of precision as the Latin ones, shall be, like them, binomial or strictly generic and specific in form. We thus have systems of names made up in which ordinary vernacular names are utilised to a considerable extent, yet of course it is constantly found that such common names do not exist at all, or if they do, that they will not fit in with the scientific limitations and precision of the various genera dealt with, consequently new names have to be coined, often by anglicising the Latin ones or by translating them, or by adopting them bodily as English words. And as these names in imitation of the scientific ones must be binomial, animals and plants which used to have only one like the Jackdaw, must needs have two, so we must say the Jackdaw Crow! The result is a set of names which are mostly as unknown to the public as those which they are meant to replace.

To take an example from Botany, the late Mr Bentham in his

"Handbook of the British Flora," a work "specially destined to assist the unscientific botanist in the determination of British Plants," though indeed a very considerable amount of scientific knowledge is necessary to rightly understand and use the terms employed in the descriptions, has made up a set of English names, to which he gives precedence even over the Latin ones, and in framing which he habitually thrusts aside the real vernacular names of the plants. Thus in order that the species of *Lychnis* may have a common generic name, he adopts Lychnis as an English word, and so the White Campion becomes the White Lychnis, the Red Campion the Red Lychnis, the Corncockle the Corn Lychnis, the Ragged Robin the Meadow Lychnis, the Common Chickweed is the "Chickweed Starwort," but as the Mouse-ear Chickweed belongs to another genus, we must call it the "Common Cerast."

Then for an example in Zoology. In M'Gillivray's "British Birds," we find a system of English names on the same principle, where the Long-Eared Owl becomes the Mottled Tufted-Owl, the Short-Eared Owl the Streaked Tufted-Owl, the Scops-Eared Owl is the Aldrovandine Owlet, the Snowy Owl the Snowy Day Owl, the Little Owl the Bare-toed Day Owl, and so on.

The great objection to this idea is, that it serves no purpose. When we talk or write about organisms from a scientific point of view, we must and will use the current and authorised scientific nomenclature, and no other can serve any purpose but confusion. And when we talk familiarly about the common animals and plants we see around us, we shall certainly continue to give them the names with which we have been familiar from our childhood. If we do not say *Myosotis palustris*, we shall certainly say Forget-me-not, and never think of using such a term as "Water Myosote." As no rule of priority or of universality can be applied to these names, they are useless to any one entering on the scientific study of botany or zoology; and by the non-scientific they never will be either used or understood.

It is, however, very desirable in books, museums, and botanical and zoological gardens, to append also the real and

well-recognised English names where such exist; and where they do not, it may be occasionally desirable, as well as harmless, to coin new ones. Occasionally, also, the native names of important foreign species may be given. I only protest against the futility of attempting to imitate or supplant the scientific names by a system of English ones invented and cooked for the purpose.

Many scientific generic names of plants have, of their own accord, become naturalised in our English speech, such as geranium, rhododendron, calceolaria, but in some cases have become attached to the wrong plant in the most absurd way. Nasturtium, the generic name of the water-cress, a genus of Cruciferæ, is now universally applied to the Indian cress—*Tropœolum majus*—a member of a perfectly different order, Tropæoliaceæ; while Syringa, the generic name of the lilac, is applied as a familiar term to the mock orangeblossom, *Philadelphus coronaria.* Against such misapplication of terms we have certainly a strong right to protest.

And now, gentlemen, it is time for me to fulfil the duty of resigning this Chair, to which, three years ago, you did me the honour of electing me for a second time—an honour for which you have my most sincere and heartfelt thanks. To preside at the meetings of the Society, from which I derived my first idea of the ways and doings of the scientific world, has been to me a source of pride and satisfaction; and I can only wish for the Society a further career of usefulness and prosperity, and that its Chair may in the future, as in the past, be occupied by a line of Presidents much more worthy of the honour than myself.

XXI. *Method of Consolidating and Preparing Thin Sections of Friable and Decomposed Rocks, Sands, Clays, Oozes, and other Granulated Substances.* By FRED. G. PEARCEY, Esq., of the "Challenger" Expedition. [Plate XI.]

(Read 17th December 1884.)

During the cruise of H.M.S. "Challenger," a large collection of oceanic deposits was obtained, among which were many concretions, soft fossiliferous limestones, decomposed

rocks, pumice and manganese nodules, volcanic *débris*, minerals, sands, clays, and oozes. On examination of a great many of these specimens, it was found impossible to determine their structure accurately without making transparent sections of them; and on account of their extreme friability this was found quite impossible by the usual method of preparing rock sections, namely, by the lapidary's wheel. It was therefore necessary to find some method of rendering them hard and compact, so that they could be subjected to this process. To attain this end, experiments were made with various substances, and after many failures and much labour a method was devised, which has proved successful, and will be of great service to mineralogists, geologists, and others in investigating the composition of soft rocks, sands, etc.

I have received Mr Murray's permission to describe the method finally adopted. The principle of the method consists in the introduction of some foreign substance to cement the grains together, and make the material to be examined hard and compact, before it can be ground or cut into thin and transparent sections. The method is carried out by soaking the substances of which sections are desired in a solution of gum copal in ether, and then evaporating the ether—a method which, I understand, is in use by some naturalists for making sections of the hard parts of Echinoderms.

Preparation and Use of the Cement.

The first process consists in preparing a solution of gum copal in ether. Take one-half pound of the best gum copal and place it in a strong glass jar, sufficient to hold about one quart, which must have a finely ground stopper, so as to make it perfectly air-tight, otherwise the ether will quickly evaporate and the gum copal will be wasted; add to the gum copal about 20 fluid ounces of ether B.P., the specific gravity of which is ·735. This composition should stand for at least two days, during which time it should be shaken frequently, or stirred with a glass rod; when all the gum copal is dissolved, it should form a clear, thin, transparent

liquid, and is then ready for immediate use. I find nothing else will dissolve the gum copal so well; other things which were tried only caused it to form a thick white gelatinous mass, quite unfit for the purpose required, and care should always be taken to procure the best gum copal, as some kinds dissolve more readily than others.

The substance required to be hardened should be first well dried in a porcelain dish (Pl. XI., Fig. 4, *a*, *b*) upon a hot iron plate placed upon a tripod stand over the flame of an ordinary Bunsen burner. The material is next placed in a porcelain crucible (Pl. XI., Fig. 3, *a*), varying in size according to the amount of substance required. About twice the volume of the solution of gum copal and ether should then be poured upon it, always taking care to press the stopper of the bottle well in afterwards. This part of the work should never be done near a fire or gas light.

The crucible containing the substance is next placed upon the hot iron plate, care being taken to have a slow or moderate heat at first, and to allow the mass to simmer till the ether has partly evaporated, when a greater heat may with safety be applied. If the substance be a fine sand or ooze of any kind, it must be well stirred with a needle-point or small knife, otherwise it will stick to the bottom of the crucible, and not allow the gum copal to mix with it. If the specimen to be hardened be a soft, porous, or decomposed rock, it will only be necessary to turn it a few times, so that the solution may thoroughly penetrate all the pores. Great care must also be taken during this part of the operation, as the cement is of a very inflammable nature, and therefore caution is essential not only in stirring, in consequence of the gum having a tendency to stick to the sides of the crucible, but also in removing the stirring-needle to avoid contact with the flame. To prevent overturning the crucible, a strip of stout tin, slightly narrower than the depth of the crucible, and bent round so as to make one end overlap the other, so that the crucible fits in firmly (Pl. XI., Fig. 3, *b*), is very useful. This keeps it perfectly steady, and can be taken off after the substance has been boiled sufficiently.

After nearly all the ether has evaporated, the substance, if

it be of a granular nature, should form a thick stringy mass when stirred, and the operator should then be able to judge whether sufficient of the gum remains to cement the grains together; if too much has been applied, more of the substance and a small quantity of pure ether must be added, and the whole boiled over afresh. This mistake, however, seldom happens after a little practice. When there is a sufficiency of gum, the mixture should be kept boiling and well stirred till it becomes of a reddish or brown colour; sometimes it is difficult to discern the colour, as the substance interferes with it, but it can be seen in most cases. The operator, however, can easily ascertain whether it has been sufficiently boiled and has attained the necessary consistency, by taking a little out on the point of a knife, and rapidly cooling it by pressing against some cold surface, or holding it a short time in water. If it hardens immediately it has been boiled enough.

The crucible can now be taken off the hot plate, and while yet warm the substance should be scraped out with a knife, and rolled or pressed with the fingers into an oblong mass; it is then ready for moulding, or it can be laid aside and moulded at any time by gradually softening on a piece of glass or in a porcelain dish upon the hot iron plate. The moulds are easily made by cutting strips of ordinary tin four inches long and three-quarters of an inch wide, bent tightly over a round iron rod three-quarters of an inch in diameter, a small slit being cut on one side of the tin to allow the wire connected with the mould to sink below the surface of the rim; this permits the mould to stand level and close to the glass plate; take the tin off the iron rod and bind it firmly round with fine copper wire; it is then ready for use (Pl. XI., Fig. 1).

Moulding.

This must be done while the substance is quite hot and plastic. First put a piece of common flat glass three times the size of the cavity of the mould upon the hot iron plate, with the mould on the top and the notched end downwards, so as to have it perfectly flat on the glass, and when quite

hot place the substance in the mould and press it firmly in with the presser (Pl. XI., Fig. 2), taking care to let as little as possible of the substance escape from the bottom. This may be to a great extent prevented by holding the mould down with the back of a knife with the left hand, and pressing in the substance with the right.

This done, take the whole off the plate smartly, with the glass attached, and press it on another flat slab or iron plate with the left hand, and with the right pour on a little cold water, when it will immediately set hard. Next place the whole in cold water for two or three minutes, after which the piece of glass at the bottom can be knocked or broken off; then loosen the wire which fastens the mould together, and open it a little (Pl. XI., Fig. 1, *a*); the moulded substance will then drop out in the form of a very hard mass, and is ready to be cut into sections. After a little practice, the whole operation can be done in an hour.

Preparation of the Sections.

Rub down and polish one end of the moulded substance, first upon a common hone, with a slow equable motion and a steady pressure, so as to produce the desired flatness of surface, and afterwards upon a Water-of-Ayr stone to give a fine polish. It must be held quite flat, so as to prevent the stones from getting worn into a hollow, when it will be impossible to get a perfectly flat surface.

The desired flatness and polish having been secured, proceed to cement with Canada Balsam the polished surface on an ordinary glass slide 3×1 inches, or according to the size of the sections required. This is done in the same way as with hard rocks, but great care must at first be taken not to have the slide too hot, or the balsam will become too brittle. After having been properly mounted, it should be cemented round with a composition formed of four parts of resin and one of bees-wax, melted together in a crucible on a hot plate, and put round the preparation with a glass pipette; when quite cold it may then be cut with a lapidary's wheel, or ground down on a metal plate with emery powder. The slice remaining on the slide should be well cleaned and rubbed

down on the hone to the required thinness. This part of the process is the most difficult. The slides should be kept as flat as possible, and looked at frequently with the microscope, so that the first indication of disruption may be detected. The proper thinness having been obtained, the section should be at once covered with a glass cemented with balsam; but considerable practice is required in this part of the work, as the preparation, being very thin, is liable to be broken into pieces by very slight overheating. The superfluous Canada Balsam round the slice should be first carefully scraped off with a sharp-pointed knife, and the slide well washed in spirit of turpentine, using a camel-hair brush to clean the section thoroughly. A little Canada Balsam should then be dropped upon the centre of the section, and a clean covering glass, heated a little, should be laid upon it while yet warm and pressed down upon it, so as to force out the air-bubbles if any remain.

The slide on which the section still remains should not be too hot, otherwise the gum will become soft and the preparation spoiled. Several preparations may be quite easily made from one moulding, and when mounted labelled and laid aside for future examination.

Mineral particles, no matter how small, can be cut into sections in the manner described.

List of Articles used in the Process of Sectioning, Moulding, etc.

Iron tripod stand, 9 × 9 in.
Cast-iron plate, ½ in. thick, 9 in. long, and 7 in. wide.
Bunsen's burner or Spirit-Lamp.
Tin moulds of various sizes (Pl. XI., Fig. 1; 1, *a*).
Tin or iron crucible stands and holders (Pl. XI., Fig. 3, *b*).
Large mounted needles.
Fine copper wire.
Fine wire gauze.
Common hone fitted with wood.
Water-of-Ayr stone.
Hard wood or iron presser (Pl. XI., Fig. 2).
Porcelain crucibles, various sizes (Pl. XI., Fig. 3, *a*).
Porcelain dishes, various sizes (Pl. XI., Fig. 4, *a*).
Glass rods.
Glass tubing.
Glass slips.
Cover glasses, various sizes.
Small steel forceps.
Camel-hair brushes.
Bees-wax.
Resin.
Finest gum copal.
Spirit of Turpentine.
Canada Balsam.
Ether, B.P., Sp. Gr. 0·735.

XXII. *Exhibition and Remarks upon a Specimen of* Larus Kumlieni (*Brewster*), *from Cumberland Inlet, North America; also Specimens of* Xema Sabinii (*Sabine*), *and other Arctic Gulls.* By JOHN A. HARVIE-BROWN, Esq., F.R.S.E., F.Z.S.

(Read 21st January 1885).

This specimen of *Larus Kumlieni* was shot on the land at Newgummiloak,—long. 64° 30′ W., lat. 64° N., on August 20th, 1884, by Mr John Henderson, who is employed in the whale fishery annually, and was on board the steam-whaler "Maude," of Dundee, captain John Watson. Others of the same species were seen, but no more obtained. The young of this comparatively newly described species is still a desideratum in most, if not in all, European and even American Ornithologist's Collections; and has not been described, so far as I know.

Larus Kumlieni was described by Brewster in the *Bulletin* of the "Nuttall Ornithological Club," 1883, p. 216; and drawings of the primary wing-feathers are there given. A somewhat interesting account of its plumage, habitat, and presently known range, and the distinctions between it and its two nearest Arctic allies—*L. glaucescens* and *L. leucopterus*—follows. The habitat therein given is Cumberland Inlet (*auct.* Kumlien) and Greenland (Bruch.), migrating south in winter to the Bay of Fundy and Grand Menan. After giving dimensions, and noticing the distinguishing characters, Brewster says:—"In many respects *L. Kumlieni* bears a curiously close resemblance to *L. leucopterus*, ... several specimens before me being positively identical in general colouring. The only tangible point of difference seems to be, that of the peculiar wing-markings of *L. Kumlieni*. This, of course, is conclusive; but it is a matter of opinion whether it indicates a stronger affinity with *glaucescens*. . . . A large series may establish a complete intergradation; but, on the other hand, my light extreme (the type) suggests a similar transition into *L. leucopterus*."

Mr Brewster considers it highly improbable that it is a hybrid between *leucopterus* and *glaucescens*, and considers it a distinct species, "intermediate between" these species, "but, perhaps, more nearly allied to the latter, to which it bears about the same relation that *leucopterus* does to *glaucus*, the whole forming a group of gulls of high northern distribution."

As *L. Kumlieni* ranges *easterly-and-northerly* in North America, whilst *L. glaucescens* is its more *westerly-and-northerly* representative, I direct the attention of British Naturalists to these specimens, on the possible chance that one or more of the former may yet wander Britain-wards, in company with other more easily recognised species. We believe that this specimen is the first secured to a British collector, and I at once placed it (where it ought to be placed) in the collection of Mr Howard Saunders, our greatest authority on this family.

Mr Saunders informs me—*in lit.*—that a similar style of gull has been found in Alaska, but of *large* size, ranging in the group between *L. glaucus* (the larger) and *L. glaucescens* as regards characteristics, but as large as the former. This, Henshaw has named *L. Nelsoni.*[1]

The immature birds of *Kumlieni* are *very dark*, thus being more allied to *L. glaucescens* in appearance. Mr Saunders has seen the types of *Kumlieni* and *Nelsoni*, and they appear —he considers—to be "*good*."[2]

Xema Sabinii, Sabine's Gull.

The two specimens shown to-night—one an adult male, and the other an immature female of the second year—were procured on drift ice in long. 60° W., and lat. 64° N., by Mr Henderson. Another adult male was procured by Captain Walker on July 6th, 1884, in long. 83° W., and lat. 73° N

[1] Henshaw, "The Auk," 1884, p. 250.

[2] There is another and less satisfactory species—*L. schistasagus* (Stejneger)—*op. cit.*, "Auk," p. 231,—from the coast of Kamtschatka (which has nothing to do with the above group), which Mr Saunders is inclined to think is the *Larus affinis* of the Petchora in North Russia (*vide* the *Ibis*, 1876, Seebohm). [I mention it as an *Arctic* species in this connection. J. A. Harvie-Brown.]

It is exactly similar to the adult exhibited to-night.[1] It would thus appear that the area frequented by this species is not so circumscribed as is usually supposed, and as recorded by naturalists; or, it may be possible that it is a comparatively recent species, only now extending its influence and range—though this is scarcely likely, if we consider that it is a species of very marked differentiation.

Mr Henderson states that he saw "many Sabine's gulls" whilst engaged in capturing bottle-nose whales (*Globicephalus melas*, Traill), and that wherever these whales were encountered, Sabine's Gulls invariably put in an appearance. He is of opinion that the same circumstances or conditions—whatever these may be—bring them together. Unfortunately, he neglected to examine the stomachs of the gulls, or to compare the contents with those of the stomachs of the whales. This, however, he will attend to in future voyages, as well as obtain as full information as possible in regard to the range, migrations, food, and habits of this interesting species. Mr Henderson's father, who sent me these gulls, says that he has tried, until he is tired, to get the whalers to collect information; but, he says, "they seem so absorbed—mentally and physically—in blubber, that nothing else can be squeezed out of them." It is therefore doubly interesting and valuable to know that we have, at least, *one* capable and willing collector, in the person of Mr John Henderson, who visits regularly these high Arctic regions in a whaler.

In conclusion, I wish to say, that very possibly—nay, very likely—the obscurity which still overhangs the subject of the limited faunal range of such species as these Arctic gulls—more especially such as *Rhodostethia Rossii* (the roseate gull)—Sabine's Gull, and besides all the intergrading forms of the *white-winged family—glaucus, leucopterus, glaucescens, Kumlieni*, etc., etc.,—may yet be cleared off, if due attention be paid, not only to *their* distribution, and migrations *and food*, but also to the food supplies of fishes and cetaceæ; and to their range and migrations throughout these seas. An intelligent comparison between the dis-

[1] I have heard of several others in 1884, but have no particulars.

tributional areas of entomostraca and even of algæ; also of food-fishes, of cetaceæ, and marine mammals; and of Birds, *must*, at some not very distant date, raise our present knowledge of these marvellous natural phenomena, and increase our admiration of, and veneration for, the wondrous infinitude of wisdom displayed in creation, and in *creative-evolution*. Some day—let us hope—we may be able to place some such statistics as these in clear and definite tabulation, so that "those who run may read."

In conclusion, I take the opportunity of exhibiting these specimens of birds; which occurrences bear interest in connection with Distribution and Migration—viz., (*a*.) "Record Form No. 1"[1] (as appended), a Fork-tailed Petrel from the Isle of May—"Forth"—(a new locality recorded for the species); (*b*.) "Record Form No. 2" (as appended), a Little Gull—*Larus minutus*—from Kincardine-on-Forth; and (*c*.) "Record Form No. 3," a Glaucous Gull—*L. glaucus*—from the same locality.

Exhibition of an albino Herring Gull (Larus argentatus, *Lin.*), *from Spain.*

An example of an albino Herring Gull (*L. argentatus*) exhibited. It was shot by Captain Halsted of H.M.S. "Dauntless" near Lisbon in the Tagus in 1852. Dr Woodcock of Anstruther, to whom it belongs, writes me that it was the only individual amongst a large number of Gulls. The colour of the eyes were not noted, and Dr Woodcock says that any notes he has, are not at present accessible to him. The rarity of albinos amongst *Laridæ*—and indeed amongst most water birds—made me consider this *lusus* worthy of exhibition to the Society. It had previously been identified by the late Mr Gould, in London, to whom Dr Woodcock had shown it. It is now in the Collection of Dr Woodcock at Anstruther.

[1] These Records are in continuation of my previous Records of Rarities in the *Proceedings* of this Society.

Records of Rarities Exhibited to the Royal Physical Society in 1884-85.

No. of Record Form.	Date.	Locality and County or District.	Species.	Age—Ad. or Juv.	Sex—♂ or ♀.	Alone or in Company	With its own, or other Species.	Comparative Nos.	Flying in which Direction when shot, caught, or seen.	If caught at a Lantern Light, on which side—N., N.E., N.W., S., S.E., or S.W.	Direction of the Wind at the time, Strength, and Weather.	Prevailing Winds for past . . . days or . . . weeks.	Time of Day or Night.
1.	1884. Aug. 15.	Isle of May. "Forth."	Fork-tailed Petrel, *Procellaria leucorrhoa* (Vieill.).	Ad.	?	Alone.	...	...	Not recorded.	...	...	...	...
2.	1884. Dec. 17.	Kincardine Ferry. "Forth."	Little Gull, *Larus minutus* (L.).	Ad.	..	..	.			...	Lt. N.E.; after strong N.E. Haze.	Strong N.E., and heavier at Sea—several days.	?
3.	1885. Jan. 21.	Kincardine-on-Forth. "Forth."	Glaucous Gull, *Larus glaucus* (L.).	Juv.	...	In Co.	Own; and other.	Few; and thousands.	..	..	Easterly. Frost.	E & N.E. St. & lt., or calm. Rarely Westerly.	...
4.	1884. Mar. 31.	Pentland Skerries. "Sutherland"	Black Redstart, *Ruticilla titys* (Scop.).	Ad.	♂	Alone.	...	.	...	...	Strong S.E. Haze.	S. & S.E., 25th to 31st.	.
5.	1884. Oct. 24.	Isle of May. "Forth."	Black Redstart, *Ruticilla titys* (Scop.).	Ad.	♂	In Co.	Own.	One.	...	..	Very lt. S. Haze.	S. on 23d. Lt. W. on 22d, 21st. Fresh W. on 19th.	10 a.m.
6.	1884.	Girdleness. "Dee."	Fork-tailed Petrel, *Procellaria leucorrhoa* (Vieill.).	..	...	...	Alone.	...	..	At East side.	O Haze.	?	Midnight.

REMARKS.

No. 1. FORK-TAILED PETREL.

If with any other species, name them here:—

Other East Coast Stations whence we have records of this species are Girdleness (*see* No. 6).

Destination of Specimen.—Isle of May Collection (Curator, Joseph Agnew).

Name of Capturer and Recorder.—J. Agnew and J. A. Harvie-Brown.

Footnote.—Remarks may consist of any further Field or Cabinet Remarks of Collector or Recorder.

No. 2. LITTLE GULL.

Myriads of other species of Gulls for the last six weeks, and myriads of "Garvies" or Sprats (*Clupea sprattus*). Gulls identified were G. B. B Gulls; Glaucous (3 shot—Evans and Harvie-Brown—*see* No. 3 below); Herring Gulls, Lesser B. B. Gulls, Kittiwakes, Black-Headed Gulls, besides Little Auks, Razorbills, Puffins, etc., unusually abundant in the Firth.

Shot by Mr J. Wells, Kincardine, and purchased by J. A. H.-B. on 19th December.

Now *in Mus.*—H. W. Feilden and J. A. Harvie-Brown.

Another specimen has since been obtained at the same locality by Mr Evans. These are the first recorded from the Firth of Forth.

No. 3. GLAUCOUS GULL.

Along with a few of its own and thousands of other Gulls (*see* No. 2) There were also two Great Skuas in the flight (*Lestris catarractes*).

Shot by Mr J. Wells, and forwarded to J. A. Harvie-Brown.

In Mus.—Feilden and Harvie-Brown. Recorded by J. A. H.-B.

No. 4. BLACK REDSTART.

This is the second record of this species at Pentland Skerries in spring, and we can scarcely doubt that it is a regular place of call of many rare or Continental species on migration.

No. 5. BLACK REDSTART.

If with any other species, name them here:—Starlings, Larks, and Gold Crests at lantern previous night, and rested on island all day; Chaffinches, 2 Fieldfares, and about 40 Hooded Crows and 1 Carrion Crow. All appeared to come from the south.

This Black Redstart was shot on the top of the wall over the porch of the lighthouse at 10 A.M. Another bird of the same species was observed next day.

No. 6. FORK-TAILED PETREL.

Caught whilst trying to alight on the rail beside the light on the east side of the lantern about midnight. The stomach contained nothing but an oily substance (Geo. Sim, Aberdeen, *in lit.*). The specimen was preserved for "a gentleman in London" by Mr Geo. Sim.

Caught by Mr M'Alister; recorded by J. A. H.-B.

NOTE.—The lately discovered breeding-place of this species—North Rona—may possibly have been (?) the starting-point of this specimen.—J. A. H.-B.

The absence of notes in two of our columns is to be regretted, but it is hoped that our lighthouse reporters will attend better to these data in future. The schedules show signs of improvement annually.

JOHN A. HARVIE-BROWN,
Member of Committee on Migration of Birds,
British Association, 1879-1885.

XXIII. *Recent Additions to the Invertebrate Fauna of the Firth of Forth.* By J. R. HENDERSON, Esq., M.B., Scottish Marine Station, Granton.

(Read 17th December 1884.)

The following species of invertebrates, which I am about to submit to the members of the Royal Physical Society, have not previously been recorded from the Firth of Forth. With the exception of a few which have lain unidentified in my collection for a year or two, they have all been taken since last August, when I commenced to work at the Granton Marine Station, where the facilities for collecting are of a high order. The record of Firth of Forth invertebrates is still very incomplete, and much work must be done in many of the groups—more especially the Sponges, Worms, Crustacea, and Polyzoa—before the list can be said to be a full one.

Most of my attention having been devoted to the Crustacea, the largest number of additions occurs in this group; and as both Mr Cunningham and I have made extensive gatherings of Copepoda, etc., I hope yet, if possible, to form lists of these more minute, though not less interesting, organisms. My warm thanks are due to the Rev. A. M. Norman, D.C.L., for kindly examining many of the species in the list,—especially among the Crustacea,—and also for many useful hints on the identification of marine invertebrates.

In all cases where "Newhaven" is given as the locality, it must be understood that the specimens are from the fishermen's lines, and probably taken to the east of the May Island.

FORAMINIFERA.

Astrorhiza limicola, Sandahl.

Half a mile west of May Island, 20 fathoms. Bottom, sandy mud. October 7th.

Mr Pearcey kindly identified my specimen. The species has been previously recorded from Dunbar by the late Prof. F. M. Balfour.

PORIFERA.

Ascandra variabilis, Haeckel.

May Island, between tide-marks on *Cladophora rupestris* (J. T. Cunningham).

Suberites (*Hymeniacidon*) *ficus* (Esper.).

Several specimens adhering to old univalves, taken in the trawl, two miles east of Inchkeith.

Isodictya fucorum (Johnst.).

On Hydroids, Newhaven. Several specimens dredged north-east of Inchkeith.

HYDROIDA.

Coryne Van Benedenii, Hincks.

On a *Buccinum* shell, tenanted by *Eupagurus bernhardus*, taken in a few fathoms off Granton Quarry.

Heterocordyle Conybearei, Allman.

On old shells of *Aporrhais* and *Turritella*, west of May Island, 20 fathoms.

Campanularia Hincksii, Alder.

On Hydroids, Kirkcaldy Bay.

Halecium sp.

A minute form, differing from all previously described British species. It is

distinguished from *H. tenellum*, which is apparently its nearest ally, by several characters constant in all my specimens. The reproductive gonophores have not yet been found. On Hydroids, taken up by a "long line," 60 miles east of the May Island.

Sertularella tenella (Alder).

Dredged to the east of Inchkeith, on other Hydroids. I have several other specimens, and believe this species to be not rare in the Firth.

VERMES.

Tomopteris sp. (*T. onisciformis*, Eschscholtz ?).

Off May Island in surface-net, November 20th; off Inchkeith, November 29th.

[1] *Filograna implexa* (Berk.).

Large masses of tubes occasionally brought in by the Newhaven fishermen.

Most of the Worms we have taken in the Firth have not yet been identified.

PYCNOGONIDA.

Nymphon hirtum, Kröyer = ? *N. hirtum*, O. Fab.

A single specimen, half a mile west of May Island, 20 fathoms; in trawl, east of Inchkeith.

N. brevirostre, Hodge.

Occasionally at Newhaven.

N. grossipes, O. Fab.

Newhaven, not uncommon; also dredged in several parts of the Firth.

In addition to these Pycnogonids, we have at least two other species, which I have not yet been able to identify.

[1] I find that this species, though omitted in Messrs Leslie and Herdman's list, was recorded from the Firth of Forth, by Mr W. S. Young, in *Proc. Roy. Phys. Soc.*, 1862.

CRUSTACEA.

Amphipoda.

Hyale Nilssoni (Rathke) (*Allorchestes Nilssoni*, Bate and Westw.).

Granton Quarry, common; May Island, near high water.

Stenothoë pollexiana (Bate) (*Montagua pollexiana*, B. and W.).

Newhaven.

Ampelisca aequicornis, Bruzel.

West of May Island, 20 fathoms.

Iphimedia obesa, Rathke.

Newhaven, many specimens. Dredged to east of Inchkeith.

Pherusa bicuspis (Kröyer).

Newhaven.

P. fucicola, Leach.

With the last.

Calliopius bidentatus, Norman.

Newhaven, many specimens. Dredged off Fidra, 12 fathoms.

Aora gracilis, Bate.

Newhaven, many specimens. Both sexes off Fidra.

Noenia tuberculosa, Bate.

Dredged to the east of Inch Mickery; also south-west of Inchkeith.

N. excavata, Bate.

With the last, in both localities.

Corophium tenuicorne, Norman.

This species was described by Dr Norman in his Report on Shetland Crustacea in the British Association Report for 1868. Two specimens alone were taken in St Magnus Bay. It does not appear to have been again met with till last October, when I dredged a single specimen off Fidra in 12 fathoms water.

Hyperia oblivia, Kröyer (Bate and Westw.).

Several specimens taken free in the tow-

net, off May Island; also off Inchkeith. There appears to be some doubt as to whether the species described by Bate and Westwood is the same as that of Kröyer.

Proto ventricosa, Müll. sp. (*P. pedata*, B. and W.).

Newhaven, not uncommon.

Isopoda.

Tanais vittatus, Rathke.

May Island and Dunbar, about half tide, living chiefly among mussels.

Jaera albifrons, Leach.

Common at the May Island, Granton Quarry, and probably many other places in the Firth, under stones near high-water mark.

Idotea linearis (Penn.).

Occasionally at Newhaven.

Cumacea.

Diastylis laevis, Norman.

Off Fidra, 12 fathoms.

According to Dr Norman this is the commonest *Diastylis* in our seas. The *Alauna rostrata* of Goodsir is perhaps referable to this species.

Schizopoda.

Nyctiphanes (*Thysanopoda*) *Norvegica* (M. Sars).

Many specimens taken in the surface-net, north-east of Inchkeith, 29th November; one or two in the same locality a few days subsequently. All the specimens small, and many immature.

Podopsis Slabberi (Van Ben.).

This species, not previously recorded from the British seas, was first taken by Mr Cunningham and myself, in the surface-net below Grangemouth, on October 8th.

I have since taken many specimens close inshore near Granton Quarry, also between Inch Mickery and Inchkeith.

It was originally described by Van Beneden in his "Récherches sur la faune litterale de Belgique," and is figured and described more recently by Prof. G. O. Sars in his monograph of the Norwegian Mysidæ.

DECAPODA.

Hippolyte pusiola, Kröyer (*H. Andrewsii*, Kin.; *H. Barleei*, Bate).

Newhaven.

Eupagurus pubescens (Kröyer) (*Pagurus Thompsoni*, Bell).

West of May Island, 20 fathoms. The variety without hairs on the chelæ was taken two miles east of Inchkeith. Specimens change to a beautiful red colour when preserved in spirits for a short time.

POLYZOA.

Membranipora Dumerilii (Audouin).

South of Inchkeith, 12-16 fathoms; common on old bivalves.

Cribrilina annulata (Fabr.).

With the last; on old bivalves.

Porella concinna (Busk).

On *Mytilus modiolus*, Newhaven, 1883.

Diastopora obelia (Flem.).

Rather common on *Mytilus modiolus*, brought in by the Newhaven boats.

MOLLUSCA.

Pecten striatus, Müll.

Single valves at Newhaven rarely, and dredged off May Island. A living specimen south-east of the Bass Rock, 16 fathoms.

Astarte sulcata (Da Costa) var. *Scotica.*
Newhaven not common.

Tellina pusilla, Philippi.
A single valve west of May Island, 20 fathoms.

Lyonsia Norvegica (Chemn.).
A single broken valve at Newhaven.

Odostomia rufa (Philippi) var. *fulvo-cincta* (Thomps.).
One living and several dead specimens, west of May Island, 20 fathoms.

Natica Montacuti, Forbes.
Living specimens rather rare at Newhaven; west of May Island, dead.

There was also exhibited a glass float, which had been sunk accidentally to the bottom of Granton Quarry—in salt water—for a few months. It was partly covered with Ascidians, including several large specimens of *Ascidia scabra,* Müll.

XXIV. *On* Loligopsis *and some other Genera.* By William E. Hoyle, Esq., M.A. (Oxon.), M.R.C.S., F.R.S.E., Naturalist to the "Challenger" Commission.

(Read 17th December 1884.)

[*Published by permission of the Lords Commissioners of the Treasury.*]

An attempt to deal with the numerous and somewhat heterogeneous forms which have at various times and by different observers been referred to the genus *Loligopsis* hardly requires any apology. If any were needed, it would be sufficient to say that 18 species have been at different times so placed, and that by different observers these forms have been referred to no less than eight distinct genera,[1] and that

[1] Since this paper was read, Dr Pfeffer (*Abhandl. Naturwiss. Verein Hamburg,* Bd. viii., Heft 2, 1884) has added another species to this list, and one more to the number of genera in which the previously described species have been placed. Of Dr Pfeffer's *Loligopsis Schneehageni,* I can only at present remark that it seems to me to have no claim to stand in that genus as defined by Lamarck; if the genus be taken as defined by d'Orbigny, then its proper position would most likely be the genus *Taonius,* but there are some

the most recent authorities are far from being in accord as to their proper positions.

LOLIGOPSIS, Lamarck, 1812.

Loligopsis, Lamarck.
,, (pars), d'Orbigny, Tryon, de Rochebrune.

The genus *Loligopsis* was founded by Lamarck for the reception of a species observed and drawn by Péron and Lesueur. Only two facts are known to us about this creature—(1.) it had eight arms, (2.) it resembled *Sepiola*, except that its fins were rhomboidal and not rounded—but these are quite sufficient to show that it had but little resemblance to the forms which have been called *Loligopsis* by subsequent writers.

In 1839 d'Orbigny took Lesueur's *Loligo pavo*, named it *Loligopsis pavo*, and then proceeded to draw up a full generic diagnosis based upon this specimen and upon another which he erroneously regarded as belonging to the same species (see *postea*). With regard to *L. Peronii*, he naïvely says—"dans tous les cas, j'ignore si cette espèce est ici bien à sa place;" but as Steenstrup aptly remarks—"since *L. Peronii* is the type it must be in its place in the genus *Loligopsis*, and it is the other species which are out of place."[1]

The type species does not appear to have been observed again, so that for the present the genus *Loligopsis* admits of no adequate diagnosis, and must therefore be used in no other sense than as containing simply the type species. It has been suggested that *L. chrysophtalmos* (Tilesius) is nearly allied to it, and judging from the figure, which represents a *Sepiola*-like animal with eight arms, this seems possible.

Loligopsis Peronii, Lamarck, 1812.

1812. *Loligopsis Peronii*, Lamarck, Extrait de son Cours de Zool., p. 123 (*fide* d'Orb.).
1821. *Sepia sepiola* (?), Lesueur, Journ. Acad. Nat. Sci. Philad., vol. ii., p. 100.
1821. ,, *minima* (?), *Id.*, *Ibid.*

points in the description which indicate that it may require the erection of a new genus for its recéption.

[1] Overblik, p. 86 (18).

1822.	*Loligopsis Peronii,*	Lamarck, Anim. s. Vert., t. vii., p. 660.
1823.	*Loligo* ,,	Blainv., Journ. de Phys., t. xcvi., p. 124.
1845.	*Loligopsis* ,,	d'Orb., Céph. Acét., p. 323; Moll. viv., p. 372.
1861.	,, ,,	Steenstrup, Overblik, p. 85 (17).
1879.	,, ,,	(pars), Tryon, Man. Conch., p. 164.
1882.	,, ,,	Verrill, Ceph. N. E. Amer., p. 125.
1884.	,, ,,	Rochebr., Monogr. Loligopsidæ, p. 16 (8).

As above mentioned this is the type of the genus, and although de Blainville (*loc. cit.*) has supplied a few details (triangular shape of the fins separately, gelatinous translucent opaline appearance of body) not given by Lamarck, it seems quite possible that the species, if again discovered, will not be recognised; and it seems, therefore, that the best course would be to allow this species to remain as a doubtful quantity for naturalists to pursue, but with which nothing can be done at present. This course is suggested by Professor Verrill (*loc. cit.*), and it was also that adopted more than twenty years ago by Professor Steenstrup, our greatest living authority on the Cephalopoda.[1]

TAONIUS, Steenstrup, 1861.

Loligopsis (pars), d'Orbigny, Tryon, de Rochebrune, etc.
Desmoteuthis, Verrill.
Procalistes, Lankester.
Phasmatopsis, de Rochebrune.

The genus *Taonius* was established by Steenstrup in 1861 to include *Loligo pavo,* Lesueur, and a new species from Greenland, which he called *Taonius hyperboreus.* So far as I am aware no diagnosis of this genus has ever appeared in the English language, and I shall therefore commence by translating Steenstrup's original description.

In the first place, the whole family Cranchiæformes is characterised thus: "The mantle is *firmly united* with the head at three separate points—namely, directly in the dorsal median line, and indirectly by means of the funnel on either side of it, where there is usually a movable sliding cartilaginous articulation or hook in other Cephalopoda."[2]

Then, under the heading *Taonius hyperboreus,* he adds:

[1] Overblik, p. 85 (17). [2] *Ibid.*, p. 70 (2).

"As soon as the relations of the tentacles and the structure of the arms in the genus *Leachia* are carefully considered, it is obvious that *Loligopsis pavo*, Lesueur, and *Leachia hyperborea*, Stp., which have hitherto been referred to it, must form a separate group. For in addition to the fact that the latter species has, and the former seems to have had, tentacles, both have narrow elongated fins, which extend along a large portion of the body, and are strikingly characterised by their enormous eyes, which almost meet on the ventral surface, and by a funnel, which is shorter and smaller than that of *Leachia*. The gladius agrees very well with that of other Cranchias, but may, on the whole, be described as expanded at the inferior extremity."

"The generic name *Taonius* is chosen more especially with reference to the longest known species, whose beautiful coloured spots suggested the specific name *pavo*; how far similar spots may have been present on the body of my species *hyperboreus*, I cannot say. . . . In case a division of the genus should become desirable, I regard the older species *Lol. pavo*, Les., as the type."

It appears from these passages that Steenstrup regarded *Loligo pavo*, Lesueur, as the type of his genus, and he did not consider it essential to make a long and detailed statement of its characters, because, as we have just seen, d'Orbigny had already done this when he made the same species the basis of his definition of the genus *Loligopsis*; in other words, Steenstrup's *Taonius* is practically identical with d'Orbigny's *Loligopsis*. It is of great importance that this should be clearly understood, because in 1882 Professor A. E. Verrill constituted[1] a new genus, *Desmoteuthis*, based upon a specimen captured near the northern edge of the Gulf Stream, which he erroneously regarded as identical with *Taonius hyperboreus*, Steenstrup. Another species, *D. tenera*, Verrill, which is possibly identical with *T. hyperboreus*,[2] has since been added to the genus.

The most striking character in the generic diagnosis is "Anterior edge of the mantle united directly to the head, on the dorsal side, by a commissure, so that there is no free

[1] Céph. N.E. Amer., p. 216. [2] *Ibid.*, p. 412.

edge medially; . . . two additional muscular commissures unite the lateral inner surfaces of the mantle to the sides of the siphon." This may be compared with the first sentence translated above from Steenstrup, and with d'Orbigny's description of his genus *Loligopsis*,[1] in which occur the following words: "Appareil de résistance consistant en trois larges brides, ou attaches fixes, placés au bord même du corps, qui le lient intimement à la tête, l'une cervicale ou dorsale à l'extremité de la saillie médiane de la coquille. Les deux autres latérales inférieures au lieu ou est ordinairement l'appareil inférieur mobile." It seems almost impossible to resist the conclusion that he means hereby to describe a precisely similar structure; furthermore, in the drawing of his *L. pavo*,[2] the dorsal margin of the mantle is shown, extending on to the head behind the eye. The remainder of the definition of *Desmoteuthis* sounds almost like a translation of that of *Loligopsis*, and nowhere are they in contradiction, as any one may see who reads them side by side.

It would appear, then, that what has been already published is sufficient to show that *Desmoteuthis* must be regarded as a synonym of *Taonius*, but in addition to this I have recently had the opportunity of examining the following specimens belonging to this genus:—The type specimens of *Taonius pavo* and of *T. cymoctypus* in the Paris Museum, that of *Taonius hyperboreus* in the Copenhagen Museum, and a somewhat mutilated specimen of the same species in the "Challenger" Collection; a specimen of an unpublished species which Professor Steenstrup proposes to call *T. elongatus;* and two specimens of another new species in the "Challenger" Collection.

On the basis of this material I have drawn up the following description of the genus, which will, I think, leave no doubt as to its identity with *Desmoteuthis*:—

Body elongated, semi-transparent, head comparatively small, eyes prominent, sometimes very large. Mantle united with the back of the head by a firm band, which widens posteriorly, the

[1] Céph. Acét., p. 320; Moll. viv., p. 368.
[2] Céph. Acét., pl. iv., fig. 1; Moll. viv., pl. xxiii., fig. 6.

surface of the back either directly continuous with that of the head, or marked off, if at all, by an exceedingly slight fold. Mantle also connected with the body at either side of the base of the funnel. Funnel devoid of a valve, but possessing Verrill's organ.[1] *Fins meeting at the posterior end of the body usually in a point. Arms short compared with the body, furnished with two rows of globular suckers. Tentacles present, and bearing four rows of suckers on the distal extremity* (T. pavo *doubtful as regards the last point, owing to mutilation*). *Gladius long and narrow, somewhat expanded towards the fins and forming a hollow pointed cone behind.*

Taonius pavo (Lesueur), Steenstrup.

1821. *Loligo pavo*, Les., Journ. Acad. Nat. Sci. Philad., vol. ii., p. 96, pl.
1823. ,, ,, Blainv., Journ. d. Phys., t. xcvi., p. 133.
1839. *Loligopsis pavo* (*pars*), d'Orb. et Fér., Céph. Acét., p. 321, Calmars. pl. vi. (exc. fig. 4), Loligopsis, pl. iv., figs. 1-8.
1849. ,, ,, Gray, B. M. C. Moll., part i., p. 40.
1861. *Taonius* ,, Stp., Overblik, pp. 70 (2), 84 (16).
1879. *Loligopsis* ,, Tryon, Man. Conch., p. 163.
1882. *Taonius* ,, Verrill, Ceph. N. E. Amer., p. 130.
Desmoteuthis hyperborea (?), *Id.*, *Ibid.*, p. 126.
1884. *Loligopsis pavo*, Rochebr., Monogr. Loligopsidæ, p. 13 (5).

As above mentioned, this is the type of the genus *Taonius*. It has also been described at considerable length by d'Orbigny, and with a considerable amount of illustratiou; but, unfortunately, he has based his description upon two specimens which are by no means identical, a fact which was first pointed out by de Rochebrune (*loc. cit.*), who has entered one of them in his Monograph as *Loligopsis pavo* (the type of Lesueur), the other (the specimen from Madeira) as *Phasmatopsis cymoctypus*.

It becomes therefore essential to inquire what parts of d'Orbigny's description refer to each several specimen, and, thanks to the courtesy of Dr de Rochebrune, I am able to give some information on this head.

[1] By this name I denote an apparatus which has been found in every species of *Taonius* examined by me, except *T. cymoctypus*. It consists of two pads within the funnel near its base, and a little posterior to them in the middle line one or two tubercles. It is figured by Verrill, who first noticed it, in his *Desmoteuthis tenera* (*loc. cit.*, Pl. xlv., Fig. 2*d*).

The phrase "Longueur totale, plus d'un mètre," refers to the Madeira specimen, while, curiously enough, the remainder of the dimensions are taken from that of Lesueur.

The general form of the body is the same in both, the tentacles are absent in both cases, but in Lesueur's the stems remain, while in the larger individual they have been cut off close to the roots.

Of the figures, Pl. vi., Figs. 1, 2, 3, are copied from Lesueur's originals. Pl. iv., Figs. 1-6, might have been taken from either, while Figs. 7, 8, were certainly taken from the Madeira specimen, for the typical *Loligo pavo* has no sharply-toothed suckers, but those even at the extremity of the arm are provided with blunt teeth, though they are not so square-cut as those of the basal suckers.

The gladius (Pl. vi., Fig. 4) was probably drawn from the Madeira specimen, from which it has been removed, though incompletely, the posterior tip remaining in the animal.

One expression used by de Rochebrune in speaking of Lesueur's specimen is unfortunate,—he says of the arms (*loc. cit.*, p. 5): "1 serie cotyledonorum armatis," while d'Orbigny, in his generic diagnosis and in his figure, gives two rows. In point of fact, the two expressions are almost equally correct; there are either two rows of suckers not far removed, or one row arranged in a zig-zag manner which in certain positions appears like one straight row.

I have already given reasons for thinking that *Desmoteuthis* is synonymous with *Taonius*. I shall now adduce a few arguments which lead me to believe that the specimen which Verrill obtained from the northern edge of the Gulf Stream, and which he believed to be identical with *Taonius hyperboreus*, was none other than *Taonius pavo*.

That it differs from the former of these may be seen by a most cursory examination of the type specimen, or of the drawing to be published in the report on the "Challenger" Cephalopoda, and as may be also seen by a careful comparison of Verrill's figures with Steenstrup's description.[1] *Taonius hyperboreus* is there defined by its differences from *T. pavo*, viz.: "(1.) the length and breadth of the fin, which is half

[1] Overblik, p. 84 (16).

the length of the body and six times as long as broad; (2.) in the large and almost regularly spherical suckers, which are several times larger than those of *T. pavo*, and especially on the lateral arms attain an astonishing size, so that the largest have a diameter as great as the breadth of the arm; and (3.) in the presence of a toothed marginal membrane along all the arms."

In every one of these characters it will be noticed that Professor Verrill's specimen differs from *T. hyperboreus*, and inclines rather to *T. pavo;* and further, a careful comparison of his figures and description with those of *Loligopsis pavo* (Les.), d'Orb., places it beyond all reasonable doubt that these are identical.

The general shape of the body is practically identical in the two forms, but the fin is produced in Verrill's drawing into "a long acute tip," which does not appear in Lesueur's, but which may very well have been present originally, for the posterior extremity of the type specimen has been injured.

The arms are not complete, "except those of the third and fourth pairs, which are nearly equal in length, the ventral ones a little the shortest and most slender" in both specimens. In both specimens, too, "the arms are all united together by a thin, delicate basal web, which extends up some distance between the arms, . . . and then runs along the sides of the arms, as broad, thin, marginal membranes."

As regards the horny rings of the suckers, d'Orbigny figures two from the base of an arm which may have been taken from this species, and which have square-cut teeth somewhat variable in number. The sucker figured by Verrill from the middle of one of the lateral arms (third pair) resembles these very closely, and he adds that "toward the tips of the arms the smaller suckers again become deeper, with more contracted apertures, and with a few more prominent denticles on the rings;" but he does not allude to the conspicuously four-toothed suckers characteristic of *T. cymoctypus*, which so careful an observer could not fail to have noticed had they been before him.

The general shape of the sucker, too, agrees fairly with that figured by Lesueur.

Verrill's account of the pen of his *D. hyperborea* describes that of *Loligo pavo*, Lesueur, very well, for the latter, like the former, terminates posteriorly in a hollow cone. This is not shown in Lesueur's drawing, though it is quite evident in the specimen; the drawing indeed is merely a sketch giving a general idea of the form of the pen, which has never been removed from the specimen.

The passages in quotation marks above are taken from Verrill's description, and when compared with d'Orbigny's figures, they leave, I think, little room for doubt that the two species in question are the same. Of course at present the identification lacks the crucial test of comparison of the actual specimens, and therefore I append a query to *Desmoteuthis hyperborea* in the synonymy.

Taonius hyperboreus,[1] Steenstrup.

1856. *Leachia hyperborea*, Stp., Hectocotyldannelsen, p. 200.
1861. *Taonius hyperboreus*, *Id.*, Overblik, p. 83 (15) (*non* Verrill).
1879. *Loligopsis hyperborea*, Tryon, Man. Conch., p. 162.
1882. *Desmoteuthis tenera* (?) Verrill, Ceph. N.E. Amer., p. 216.
1884. *Loligopsis hyperborea*, Rochebr., Monogr. Loligopsidæ, p. 12.

The Body.—The body is elongated, tapering posteriorly; the *mantle* is thin, enclosing an enormous branchial cavity, only a small portion of which is occupied by the viscera; its anterior border projects slightly forwards in the middle line dorsally and at each lateral attachment; in the former of these positions the surface of the body is almost continuous with that of the head, only the very slightest fold of the mantle marking them off. A number of purplish chromatophores cover the mantle, and there are also a number of larger spots disposed in irregular rows, of which there are about ten down the mantle. The *caudal fin* is fully half the length of the body and of an elongated cordate form. The *siphon* is triangular, and reaches to about the centre of the

[1] This species will be figured in the forthcoming Report on the "Challenger" Cephalopoda.

head; on its dorsal wall, immediately behind the aperture, are two low cushion-like papillæ in the middle line, and behind these three long-pointed papillæ arranged in a triangle with the apex directed forwards.

The Head.—The head proper is small, much smaller than either of the enormous globular eyes, which occupy the whole of its two lateral surfaces.

The Arms.—The *sessile arms* are short, on an average about one-third the length of the body; their order of length is 3, 2, 1, 4; a toothed membrane extends along the arms, but forms only a very small web between them. They are furnished with two rows of suckers most numerous and closely packed on the dorsal arms. The *suckers* are subglobular, the proximal half of the globe being opaque and muscular, the distal corneous and semi-transparent. The suckers on the dorsal and ventral arms are subequal, and also on the lateral arms for the proximal half of their length; on the third quarter are situated about eight large suckers, whose diameter fully equals that of the arms; on the terminal fourth the suckers gradually diminish. The margin of the larger suckers is almost entire but marked out into irregular very shallow, square-cut teeth; on the distal margins of the smaller suckers the teeth become more prominent, but are blunt, and about 8 to 10 in number. The *tentacles* are but little longer than the arms, and only slightly expanded at their extremities. On the inner side of the stem is a groove which bears two and afterwards four irregular rows of very minute suckers, among which are a number of fixing-cushions (*Hæftepuder*, Steenstrup). On the club are four rows of suckers about as large as the smaller ones on the arms; their horny rings are provided on the proximal semi-circumference with about fifteen closely set sub-acute teeth, while the distal semi-circumference bears about nine long very acute teeth.

The Shell.—The pen is long, narrow anteriorly, expanded in the posterior half, and forming a hollow terminal cone enclosing part of the genital gland.

Taonius cymoctypus (de Rochebrune), mihi.

1839. *Loligopsis pavo (pars),* d'Orb., Céph. Acét., p. 321, pl. vi., fig. 4 (?); pl. xxiii., figs. 10, 11.

1884. *Phasmatopsis cymoctypus,* Rochebr., Monogr. Loligopsidæ, p. 17 (9).

Malacologists are indebted to Dr de Rochebrune for pointing out the distinctness of this interesting form from *T. pavo* (Les.), with which d'Orbigny had confused it, and for correcting several mistakes which had arisen in consequence in that author's great work. It is to be regretted, however, that de Rochebrune has fallen into an error which has led him to erect this species into a new genus.

His description and figure alike indicate the tentacles as present and similar to the sessile arms. A careful examination, however, of the specimen has shown me that the two ventral arms only are complete, and adjoining each of these is the stump of a tentacle, concerning the perfect form of which nothing can be made out; the remaining arms are present, but their tips are wanting.

In the structure and arrangement of the head and mantle, it does not differ from the typical arrangement in *Taonius.* The funnel contains no valve, nor is it possible to determine whether an apparatus, such as Verrill has described in his *Desmoteuthis,* was originally present.

The ventral arms only are intact, but they are somewhat stouter than any of the others. They are armed with two rows of suckers, alternating with each other, which have the same general structure as in *Taonius hyperboreus* or *T. pavo,* but differ in details. The innermost are hemispherical, with a small horny ring notched into square teeth; those from the middle of the arm are larger, but still have square teeth; while those three-fourths along the arm and beyond gradually diminish in size towards the tip, and have the horny ring divided into four conspicuous teeth on the distal side.

The suckers, which are figured by d'Orbigny as of *Loligopsis pavo,* are in reality those of this form; for those of the original specimen of *Taonius (Loligopsis) pavo* are all provided with square teeth. The suckers figured by de Rochebrune as tentacular are taken from these sessile arms, for, as above mentioned, the tentacles are absent. I did not observe

any suckers with more than four well-developed teeth, and my impression was that d'Orbigny's figure (pl. xxiii., figs. 10, 11) gave a much more accurate picture of the structure than Dr de Rochebrune's.

LEACHIA, Lesueur, 1821.

Leachia, Lesueur, Steenstrup.
Anisoctus (?), Rafinesque.
Loligopsis (pars), Gray, Tryon, de Rochebrune.
Dictydiopsis, de Rochebrune.

The genus *Leachia* was established by Lesueur in 1821 on the basis of a drawing by Mr Petit representing an animal captured in the Southern Ocean (Lesueur calls it "Pacific Ocean," although the position given is lat. 37° S., long. 33° E.). It appears to have remained unused for forty years, until in 1861 Steenstrup reconstituted it and placed in it *Loligopsis ellipsoptera*, Adams and Reeve.

Lesueur's diagnosis was short and quite insufficient for modern requirements, though no doubt the distinctions he drew were all that were required at the time he wrote.

He says: "Eight unequal arms, the third pair longer and more robust."

Professor Steenstrup gives as the grounds for his recognition of the genus, as distinct from *Taonius* and *Cranchia*, three characters,—(1.) the absence of the tentacles, present only as stumps; (2.) the broad rounded fin; (3.) two lines of cartilaginous papillæ down the ventral surface.

That Lesueur overlooked the first and last of these points is not strange, for, as we shall see further on, he had only a drawing of the dorsal surface upon which to base his diagnosis.

Adams and Reeve have overlooked the stumps of the tentacles and also the lines of papillæ down the ventral surface, in connection with which latter Steenstrup remarks: "In consequence of the great transparency of the animal, these lines are easily overlooked, and in the living animal the difficulty of their recognition is naturally much increased. It need not surprise us, therefore, that the figure of the English authors does not show them."[1]

[1] Overblik, p. 81 (13).

Brock bears out this statement, and says that it was only on repeated examination, and by feeling rather than by sight, that he discovered their existence in his two specimens.[1]

Professor Steenstrup's remarks on the tentacle stumps may also be translated. Speaking of *L. ellipsoptera,* he says—"When it is borne in mind that all the specimens of the nearly related *L. cyclura* have had precisely similar stumps, and, in so far as they have been examined with respect to this point, exactly of the same length as in these individuals, and also that two specimens in the Paris museum show the same arrangement, one is driven to the conclusion that the mutilation of the tentacles is not merely due to accident, especially as a large number of the specimens under consideration were taken alive. If these forms really at one time possessed the long tentacles of their family, then at least it must be assumed that they have some organic peculiarity which causes them to be easily broken off, and always at one and the same point. At all events, the basal remnants do not indicate that the tentacles were of extreme thinness."

In the present state of our knowledge the following may be given as a description of the genus *Leachia* :—

Body elongated, semi-transparent, head small, eyes prominent. Mantle united with the back of the head by a firm band, which widens posteriorly, and by a band at each side of the base of the siphon. A row of cartilaginous papillæ down the ventral surface of the mantle on each side. Fins terminal, forming together a broad oval or a circle. Arms short compared with the body, with two rows of suckers. Tentacles rudimentary, their stumps being situated in the usual place. Gladius long, slender, and somewhat dilated in front and posteriorly, conical and hollow behind.

Professor Steenstrup[2] suggests that *Anisoctus,* Rafinesque, may be a synonym of *Leachia,* and the brief definition given by the author is not inconsistent with such a supposition, but without the figures which are alluded to in the description, no certainty is possible.

[1] Göttingen Nachrichten, p. 507, 1884.

[2] Ommatostrephagtige Blæksprutter, p. 104 (34).

Leachia cyclura, Lesueur.

1821. *Leachia cyclura*, Les., Proc. Acad. Nat. Sci. Philad., vol. ii., p. 90, pl. vi.
1823. *Loligo Leachii*, Blainv., Dict. d. Sci. Nat., t. xxvii., p. 135.
1823. ,, ,, *Id.*, Journ. de Phys., p. 124.
1823. *Loligopsis cyclurus*, Féruss., Dict. class., t. ii., p. 68, pl., fig. 3 (*fide* d'Orb.).
1825. ,, *Leachii*, Féruss., d'Orb. Tabl. des Céph., p. 57.
1833. ,, *guttata*, Grant, Trans. Zool. Soc. Lond., vol. i., p. 24, pl. ii.
1833. *Perothis pellucida*, Rathke, Mém. Sav. Étrang. Acad. Sci. St Petersb., t. ii., p. 149.
1833. ,, *Eschscholtzii*, *Id.*, *Ibid.*
1839. *Loligopsis guttata*, d'Orb., Céph. Acét., Loligopsis, pl. i., fig. 1, pl. iii., pl. iv., figs. 9-16.
1845. ,, *cyclura*, *Id.*, *Ibid.*, p. 322; Moll. viv. et foss., p. 370, pl. xxiii., figs 1-4.
1861. *Leachia* ,, Steenstrup, Overblik, p. 82 (14).
1879. *Loligopsis* ,, Tryon, Man. Conch., vol. i., p. 163.
1884. ,, ,, Rochebr., Monogr. Loligopsidæ, p. 14 (6).
1884. ,, ,, Brock, Gottingen Nachrichten, p. 504.
1884. *Perothis Dussumieri*, Rochebr., Monogr. Loligopsidæ, p. 28 (20).

This is the type species of the genus *Leachia*, and is almost as unsatisfactory as the type of the genus *Loligopsis*, for, as above mentioned, it is founded upon a drawing which represents the dorsal aspect of a Cephalopod obtained in the South Pacific, with only indifferent attention to its anatomical characters. Happily, however, the figure has been published, and this has led d'Orbigny and others to identify the animal more or less certainly with other forms described in greater detail by Grant and Rathke. This is the more fortunate, inasmuch as Lesueur's character of his genus is about as short and fragmentary as possible—"Eight unequal arms, the third pair longer and more robust."

The identification of *L. cyclura* with *Loligopsis guttata*, Grant (*Perothis pellucida*, Rathke), has recently been called in question by Tryon and de Rochebrune. The objection of the former that Grant's species "has rows of tubercles," while "Lesueur describes and figures a smooth species," is sufficiently answered by Verrill, who aptly points out that "Lesueur only *described a figure of the dorsal surface*," which could not be expected to show the ventral tubercles.

Dr de Rochebrune's objection, so far as I understand it, seems to be of the same nature. He says—"D'Orbigny et Férussac, en attribuant ces tubercules au *Leachia cyclura* se sont mépris;" to which criticism, I take it, Verrill's remark is a sufficient rejoinder.

In such a case absolute certainty is impossible, but it appears to me that d'Orbigny was quite justified in the course he adopted. The drawings resemble each other very closely in the form of the body (except that Lesueur's is a little stouter), in the form of the fins, and in the relative dimensions of the head and eyes. Grant himself calls attention to the peduncle of the eye, which "is like a smaller eye-ball placed behind the larger exterior," and remarks that it is indicated in Lesueur's figure. The differences are that Lesueur's drawing does not show the pen passing down the centre of the back, and that the markings differ in form and arrangement.

It is clear that Petit's drawing was merely a rough sketch, witness the manner in which the suckers are represented, and taking this into consideration the correspondence is as close as can be expected.

I am unable to agree with Dr de Rochebrune in creating a new species for the specimen in the Paris Museum, which he calls *Perothis Dussumieri.* It appeared to me to be a very good example of *Leachia cyclura;* indeed, I should have had no doubt that it was actually the one depicted by d'Orbigny in his great work (pl. iv., fig. 9), and with this the locality quoted agrees. The tubercles on the ventral surface are eleven large, with smaller intermediate ones. The tentacles are truncated, and with rounded extremities, as in the typical *Leachia,* and I cannot at all understand Dr de Rochebrune's description of them as "tentacules coniques recroquevillés, à cupules sessiles arrondies, sans dents et sur une seule ligne." Is it possible that, as in the case of his *Phasmatopsis cymoctypus,* he has overlooked the stumps of the tentacles, and not observed that only four, and not five, pairs of arms were present?

Leachia ellipsoptera (Adams and Reeve), Steenstrup.

1848.	*Loligopsis ellipsoptera,*		Adams and Reeve, "Samarang" Mollusca, p. 2.
1849.	,,	,,	Gray, B. M. C. Moll., p. 40.
1861.	*Leachia*	,,	Stp., Overblik, p. 80 (12)
1879.	*Loligopsis*	,,	Tryon, Man. Conch., vol. i., p. 163.
1884.	*Dyctydiopsis*	,,	Rochebr., Monogr. Loligopsidæ, p. 18 (10).

The type specimen of this species, discovered during the voyage of the "Samarang," appears to have been lost, but there are five specimens in the Copenhagen Museum, which are beyond all doubt referable to it. The differences between *L. cyclura* and this form "consist mainly in the form of the fin and the ventral cartilaginous lines. The almost circular, slightly heart-shaped figure which the caudal fins together exhibit in the former, pass into a distinctly transverse oval in the latter. The drawing of *L. cyclura,* which represents the fins of the greatest breadth in proportion to the length, is that by d'Orbigny in his great work on the Cephalopoda, but even here each fin is longer than broad, while in *L. ellipsoptera* each fin is considerably broader than long. The cartilaginous lines on the sides of the mantle are described and depicted by Grant and d'Orbigny as ceasing about half-way between the anterior margin of the body and the fin; in our *L. ellipsoptera* they reached just over one-third this distance, and they are, too, as above stated, very weak, and their warts not so large, so prominent, or so numerous." [1]

Dr de Rochebrune has made this the type of a new genus, which, in violation of the ordinary rule for transcribing Greek names, he writes "*Dyctydiopsis;*" but I confess that I see no grounds for such a proceeding, nor do I understand where he obtained his description of the tentacles ("courts subquadrangulaires à cupules petites inégalements distribuées sur toute leur longueur"), for Adams neither mentions nor figures them.

Brock (*loc. cit.*) comes to the conclusion that *L. ellipsoptera* is merely a synonym of *L. cyclura,* basing his opinion upon

[1] "Grant's specimen seems, both from the drawing and the description, to have had these lines much more pronounced than d'Orbigny's"—*loc. cit.*, p. 82 (14).

two specimens given him by Dr Reichenbach, and regarded by him as intermediate in their characters between these two species. Probably some uncertainty will always hang over this point, as neither type specimen can be found, and the ultimate criterion of each species is only a somewhat indifferent figure.

Leachia dubia (Rathke), mihi.

1833. *Perothis dubia*, Rathke, Mém. Sav. Étrang. Acad. Sci. St Petersb., t. ii., p. 170.

This appears to be distinct from *Perothis pellucida*, but very little is known about it, for Rathke does not figure it as a whole, but merely gives two small drawings representing portions of its anatomy. It would seem, however, to be distinct from *Perothis pellucida* (= *Leachia cyclura*).

DORATOPSIS, de Rochebrune, 1884.

Doratopsis vermicularis (Rüppell), de Rochebrune.

1844. *Loligopsis vermicularis*, Rüppell, Giorn. Gab. Messina, t. xxvi. (*fide* Vérany).
1851. ,, ,, Vérany, Céph. Médit., p. 123, pl. xl., figs. *a*, *b*.
1884. *Doratopsis* ,, Rochebr., Monogr. Loligopsidæ, p. 20 (12).
,, *Rüppelli*, *Id.*, *Ibid.*, p. 21 (13).
1884. *Hyaloteuthis vermicularis*, Pfeffer, Ceph. Hamb. Mus., p. 28.

Dr Pfeffer appears to have been so fortunate as to examine Krohn's original specimen, figured by Vérany (*loc. cit.*, *b*), and he has given, what naturalists have long waited for, a complete description of it. He is not quite right in saying that its "position in the family of the Loligopsidæ has never been challenged," for it has long been known that its generic name was quite incorrect; but no naturalist cared, upon the slender information given by Vérany, to found a new genus for its reception, until de Rochebrune did so, just in time to anticipate Dr Pfeffer; this is, however, to some extent a matter for congratulation, inasmuch as the name *Hyaloteuthis* had already been used by Gray in a different sense.[1]

It does not seem yet certain that the two forms figured

[1] B. M. C. Moll., p. 63.

by Vérany are specifically distinct; the differences between them may be due to growth, or possibly to sex.

Calliteuthis, Verrill, 1882.

Calliteuthis ocellata (Owen), Verrill.

1881. *Loligopsis ocellata*, Owen, Trans. Zool. Soc. Lond., vol. xi., part 5, pp. 139-143, pls. xxvi., figs. 3-8, xxvii.
1882. *Calliteuthis* ,, Verrill, Ceph. N.E. Amer., p. 202.

There can be no doubt that Sir Richard Owen's *Loligopsis ocellata* is congeneric with Professor Verrill's *Calliteuthis reversa* (*loc. cit.*, p. 327); but the question whether they belong to the same species can only be satisfactorily settled by a comparison of the actual specimens, and must therefore be left in abeyance.

Cranchia, Leach, 1827.

Cranchia Reinhardtii, Steenstrup.

1855. *Leachia Reinhardtii*, Stp., Hectocotyldannelsen, p. 200.
1861. *Cranchia* ,, *Id.*, Overblik, p. 76 (8).
1879. *Loligopsis* ,, Tryon, Man. Conch., vol. i., p. 165.
1882. *Cranchia* ,, Brock, Zeitschr. f. wiss. Zool., Bd. xxxvi., p. 605.
1884. *Perothis* ,, de Rochebr., Monogr. Loligopsidæ, p. 28 (20).

This is a well-marked *Cranchia*, and there would be no need for its mention here had not Tryon, without the least show of reason, placed it under the genus *Loligopsis*.

Chiroteuthis, d'Orbigny, 1839.

Chiroteuthis Véranyi (Férussac), d'Orbigny.

1834. *Loligopsis Veranyi*, Féruss., Magasin d. Zool., pl. lxv.
1839. *Chiroteuthis* ,, d'Orb., Céph. Acét., p. 235, pls. ii., iv., figs. 17-23.

This is the type of d'Orbigny's genus *Chiroteuthis*, and as it is always known under this name, there would be no need to mention it here except for the sake of completeness.

Species of Uncertain Generic Position.

Loligopsis chrysophtalmos (Tilesius), d'Orbigny.

Sepia chrysophtalmos, Tilesius, Krusenstern, Voy. Atlas, pl. xxxviii., figs. 32, 33 (*fide* d'Orb.).

1845. *Loligopsis chrysophtalmos*, d'Orb., Céph. Acét., p. 324, Loligopsis, pl. i., figs. 2, 3, 4 (*L. Tilesii*).
1845. „ *chromorpha*, *Id.*, *Ibid.*, p. 324.

This is a minute creature discovered by Tilesius on Krusenstern's voyage round the world, which agrees with Lamarck's definition of the genus, in so far that it somewhat resembles *Sepiola* and has eight arms; but, as Steenstrup has pointed out,[1] the shape of the fins is rounded, not rhomboidal, there are three or four rows of suckers on the arms, and altogether the animal resembles a young *Rossia*-like creature more than anything else. Its true position will probably always remain doubtful. I cannot propose to place it in any genus hitherto constituted, still less do I intend to create a new one for its reception.

Loligopsis zygæna, Vérany.

1855. *Loligopsis zygæna*, Vérany, Céph. Médit., p. 125, pl. xl., fig. *c*, 1851.
1884. *Zygænopsis* „ Rochebr., Monogr. Loligopsidæ, p. 20.

A very beautiful little Cephalopod, evidently of pelagic habits, is figured by Vérany, but unfortunately his statements as to its anatomical peculiarities are far from giving sufficient information to enable us to fix its systematic position. The genus *Loligopsis*, as understood by Vérany, by no means agrees with the definition of d'Orbigny, which is founded mainly upon the structures connecting the head with the mantle, as observed in the *Loligopsis Véranyi* of Férussac (= *Chiroteuthis Véranyi*, d'Orb.); there is, however, no indication that such an arrangement is found in the creature under discussion, and if it were, the differences between this form and the type species would render its erection into a new genus essential.

It is worthy of notice that Vérany's drawing closely resembles two species in the "Challenger" Collection, which are referable to the genus *Taonius*, and are believed to be older forms of *Procalistes Suhmii*, Lankester; the chief differences are in the form of the fin, which is cordiform in *T. Suhmi*, and in the absence of suckers on the tentacles except at their extremities. Seeing that these differences exist, however, it would not be right to transfer *L. zygæna* to the genus *Taonius*. Dr de Rochebrune has erected it into a

[1] Overblik, p. 86 (18).

genus *Zygænopsis*, but, even were this procedure on other grounds admissible, the fact that the name proposed is preoccupied is fatal.

In concluding, I have to acknowledge my indebtedness to Professor Steenstrup, both for the opportunity of examining the collection of Cephalopods in the Copenhagen Museum and for valuable advice and assistance during the progress of my work, as well as to Dr de Rochebrune for the courtesy with which he facilitated my examination of the valuable type specimens in the Paris Museum—it is a source of great regret to me that I find myself differing from him in so many points.

List of Abbreviations Employed.

d'Orb., Céph. Acét.
Férussac et d'Orbigny, "Histoire naturelle générale et particulière des Céphalopodes acétabulifères." Paris, 1835-48.

d'Orb., Moll. viv.
d'Orbigny, "Mollusques vivants et fossiles." Paris, 1845 & 1855.

Gray, B. M. C. Moll.
Gray, J. E., "Catalogue of the Mollusca in the Collection of the British Museum; Part i., Cephalopoda Antepedia." London, 1849.

Pfeffer, Ceph. Hamb. Mus.
"Die Cephalopoden des Hamburger Naturhistorischen Museums"—*Abhandl. Naturwiss. Verein. Hamburg*, 1884.

Rochebr., Monogr. Loligopsidæ.
Dr de Rochebrune, "Étude monographique de la famille des Loligopsidæ"—*Bull. Soc. Philom. Paris*, ser. 7, t. viii., No. 1, 1884.

Steenstrup, Hectocotyldannelsen.
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XXV. *On Fossil Bones of Mammals obtained during Excavations at Silloth.* By Professor WM. TURNER, M.B., F.R.S.

(Read 18th February 1885.)

In February 1859 I exhibited and described to this Society[1] a collection of the bones of *Bos primigenius*, some of which had been for many years in the Anatomical Museum of the University of Edinburgh, and others were obtained from localities in the north-west part of the county of Lancaster. In the month of April of the same year the late Dr J. Alexander Smith described to this Society[2] some crania of the same animal preserved in the Antiquarian

[1] Proc. Roy. Phys. Soc., vol. ii., p. 71, and Edinburgh New Philosophical Journal, July 1859.

[2] Proc. Roy. Phys. Soc., vol. ii., p. 111.

Museum in this city. His paper on this subject was subsequently expanded into an excellent memoir, entitled "Notes on the Ancient Cattle of Scotland," and published in the *Proceedings* of the Society of Antiquaries of Scotland.[1] In these Notes he has collected together the accounts of all the specimens both of *Bos longifrons* and *Bos primigenius* which had up to that time been found in Scotland, and he has given a description of the crania of this animal in the Museums of Antiquities, the Free Church College, the Royal College of Surgeons, and the Veterinary College in this city.

During the years 1883 and 1884, whilst the North British Railway Company was engaged in excavations connected with the formation of a new dock and a new gas-holding tank at Silloth, remains of *Bos primigenius*, the red deer (*Cervus elaphus*), and bones of cetacea were discovered. I first heard of this "find" in 1883 through the courtesy of my friend Dr Leitch of Silloth, by whom the remains were sent to me for identification, and through his kind offices I have obtained information respecting the conditions under which they were found.[2] I am also indebted for important information as to the deposits in which they were imbedded to Charles Boyd, Esq., the resident engineer, and to J. T. Middleton, Esq., the contractor. By permission of these gentlemen and of Sir James Falshaw, the chairman of directors of the North British Railway Company, I have been able to secure several of the specimens for the Anatomical Museum of the University.

The following specimens were obtained during the dock excavations:—A portion of a skull of *Bos primigenius*, the right half of the lower jaw, the left humerus, the right tibia and the right metatarsal bone of the same animal; two antlers and the humerus of *Cervus elaphus*, and two vertebræ of cetaceans. Mr Boyd writes to me that these specimens were all found within a short distance from each other near

[1] Proc. Scot. Soc Antiq., vol. ix., p. 587, 1873.

[2] Subsequently to this paper being read to the Society, Dr Leitch sent me a copy of the *Transactions of the Cumberland and Westmoreland Association for the Advancement of Literature and Science*, No. IX., 1885, in which he had described the locality and figured some of the bones.

the south-east corner of the new dock, and were lying in a bed of wet gravel and shingle mixed with the shells of oyster, mussel, cockle, immediately on the top of the red boulder clay, and at a depth of 28 feet below the surface of the ground, 10 feet above low-water level, 16 feet below high-water level, and at a distance inland, southwards, of about 450 yards from high-water mark. The material overlying the bones was a bed of gravel or shingle 10 feet in thickness, above which 14 feet of sand intermixed with thin beds of shingle and common sea shells, varying from 2 to 8 inches in thickness, were superimposed.

Another skull of *Bos primigenius* was obtained during the excavation for the gas-holder. It was imbedded, says Mr Boyd, in soft sandy silt at a depth of 10 feet below the surface of the ground, at about high-water level, 26 feet above low-water level, and at a distance of 1000 yards inland from high-water mark in a southerly direction from the position of the bones found in the dock excavations, and at a 16-feet higher level than those bones. The soft silt overlaid the skull to a height of 5 feet; above the silt was 4 feet of alluvial clay and 1 foot of surface soil. Boring operations proved that the silt was continued to the depth of 20 feet below the surface. The collection consisted of bones both of marine and terrestrial mammals, and the locality was, in the opinion of Mr Hugh Miller, jun., of the Geological Survey, an ancient raised beach (see Appendix, p. 338).

One antler of the red deer was a very fine specimen. It was the right, and a portion of the frontal bone was attached to it. Its length in a straight line from the burr to the tip of the highest point was 33 inches. The brow point was unfortunately broken off close to the root, but the bay and tray points were both entire, the one 10½ inches, the other 8 inches long. The beam spread out at the summit, and gave origin to five points or crockets; the crocket points were somewhat rubbed, probably from friction against the gravel. The surface of the beam was grooved and tuberculated. The circumference of the beam between the burr and the brow antler was 8¾ inches. The second antler, also the right, was much smaller, and had a portion of the frontal bone attached.

It possessed the brow, bay, and tray points, but the points at the summit of the beam were broken off, so that neither their number nor the full length of the antler could be ascertained. The brow point was 10 inches long in a straight line, and the circumference of the beam between it and the burr was 7¼ inches. The bay point immediately above the brow point possessed the peculiarity of having had the free end broken across and subsequently repaired by bony union; the fracture and subsequent repair must of course have occurred when the antler was covered by velvet and before the atrophy of the blood-vessels. The humerus was of the right limb, and measured 9 inches from the head to the radial articular surface, and 2 inches across the condyloid end.

The cetacean bones consisted of two vertebræ. One, the larger, was the caudal vertebra of a finner whale, probably the *Balænoptera musculus.* The spine and transverse processes were so much broken that the full dimensions of the bone could not be obtained. The dimensions of the body were, however, taken: antero-posterior diameter, 8 in.; transverse diameter, 6½ in.; vertical diameter, 5½ in. The bone was from an adult whale, as the epiphysial plates were completely fused with the body. The smaller vertebra was a lumbar from one of the toothed whales, probably a *Globiocephalus.* The ends of the spine and transverse processes were broken off, the body also was injured, and the bone had the appearance of having been rolled about amongst the gravel. The following measurements are only approximative: height of the entire bone, 10 in.; between transverse processes, 11 in.; antero-posterior diameter of body, 4 in.; height of body, 3 in.; transverse diameter of body, 3½ in.

One skull of the *Bos primigenius,* viz., that from the dock excavation, consisted of the perfect horn cores, and the intermediate part of the cranium. The horn cores had the characteristic form belonging to this ox. The distance between their tips was 27 in.; the breadth between their most projecting convexity, 35½ in.; greatest breadth between their roots across the frontal bone, 12 in.; breadth of the supra-occipital ridge, 7 in.; girth of the base of the horn core, 12½ in. The other skull from the gas-work

was also much injured, and both the horn cores, subsequent to the discovery of the skull, were broken, the left about midway between the base and the tip, the right nearer to the tip. The greatest breadth between their roots across the frontal bone was $11\frac{1}{2}$ in.; breadth of supra-occipital ridge, $8\frac{1}{2}$ in.; girth of the base of the horn core, $12\frac{1}{2}$ in. As the occipito-sphenoid part of this skull was, however, present, the dimensions of the foramen magnum, and at the occipital condyles, were also taken. The extreme width between the two condyles was $5\frac{3}{8}$ in. The width of the foramen magnum was $1\frac{7}{8}$ in.; its antero-posterior diameter was the same.

The right half of the lower jaw of the *Bos primigenius* was almost entire, only a small part of the anterior border of the ascending ramus and the socket for the outer incisor having been broken away. As this is apparently the only specimen of the lower jaw of this animal which has been found in Britain, I shall compare its dimensions and characters with those of the corresponding part of the lower jaw of the Hamilton wild white ox in the Anatomical Museum of the University of Edinburgh.

	Fossil. Inches.	Hamilton Ox. Inches.
Extreme Length,	$18\frac{1}{4}$	$15\frac{5}{8}$
From angle to tip of coronoid,	$8\frac{1}{2}$	9
From angle to top of condyle,	$7\frac{1}{4}$	$6\frac{7}{8}$
Height of coronoid,	$1\frac{3}{4}$	$2\frac{3}{4}$
Length of molar alveoli,	$6\frac{5}{8}$	6
Height behind last molar alveolus,	$3\frac{1}{4}$	$3\frac{1}{4}$

The mandible exactly fitted the large skull of the fine *Bos primigenius* in the Anatomical Museum of that University, described by me in 1859; it belonged, therefore, to a full-grown animal. Three true molars and the last premolar were in place, the other premolars and the incisors were absent, although their sockets were present. The molars were so far worn down that a section through the external accessory lateral column was in the grinding surface of the crown. In its general configuration this bone corresponded closely with that of the Hamilton white ox, though the latter had a longer and more attenuated coronoid process; in its length,

however, the fossil considerably exceeded the recent mandible, and obviously belonged to a much larger animal.

The left humerus of *Bos primigenius* was perfect, except that the two tuberosities were injured. Its length from the head to the radial articular surface was $15\frac{3}{4}$ in.; the breadth at the condyles was $5\frac{1}{4}$ in. It was a more massive bone than the right humerus of the same species described by me in 1859. The right tibia was perfect, and a massive bone; its extreme length was $19\frac{1}{2}$ in.; the greatest breadth at the upper end was $5\frac{9}{16}$ in.; at the lower end, $3\frac{1}{2}$ in. The right metatarsal bone was perfect; its extreme length was $12\frac{1}{4}$ in.; its breadth at the upper end, $2\frac{3}{4}$ in.; at the lower end, $3\frac{1}{16}$ in. These long bones were not rubbed, but their muscular ridges and articular surfaces were sharp and well defined as in a recent bone; their dimensions, however, were considerably greater than in the skeleton of the Hamilton wild white ox. I have not thought it necessary to give the precise dimensions of the corresponding limb bones in the Hamilton ox, as their measurements have already been recorded by Dr John Alexander Smith in his "Notes," above referred to, p. 616.

Appendix on the Geology of the Silloth Dock.

By Hugh Miller, Esq., F.G.S., *H.M. Geological Survey.*

I visited the New Dock at Silloth, and examined the section, during the progress of the excavations in March 1884, about two months after the discovery of the skull of *Bos primigenius.* A year later, when there was some prospect of my notes being brought into requisition, I had occasion to revisit Silloth, and confirmed some important particulars in which my account differs from that of previous observers. On both occasions I was much indebted to the courtesy of Mr J. T. Middleton, C.E.; and in March last to that of Dr Leitch, the President of the Silloth and Holme Cultram Literary and Scientific Society, to whose paper, "Notes on the Geological Formation and Fossils of the Silloth New

Dock,"[1] I also have pleasure in acknowledging my indebtedness. Occasional notes on the same subject have been published in the same volume (p. 214) by my late colleague, Mr T. V. Holmes, F.G.S., chiefly communicated to him by Mr Goodchild.

The entire section consisted of superficial deposits, viz., a thick foundation of red boulder-clay below, penetrated to a depth of 30 feet without signs of rock; and recent marine deposits above, originally about 30 feet thick, and covered over with blown sand. The following represents the full section from the original surface to the bottom of the dock —which is on the mean low-water level of ordinary spring tides:

	Feet.
5. Blown sand, previously removed; partly re-deposited by the wind while the excavations were in progress, ...	—
4. Sea sand and fine shingle, intensely current-bedded, containing waterworn fragments of recent shells, and some lumps and thin layers of drifted peat. Mammalian bones in lower part, originally	29
3. Shell-bed; a dark and fetid-looking mash of gravel and mud. Shells unbroken; valves sometimes together. Large stones with some oysters adherent, and crusted with serpula and corallines (*Lepralia*), ... about	1
2. Unconformity, ...	—
1. Gritty red boulder-clay or gravelly till; and, in the south-east corner of the dock, laminated brick clay, ...	10

The till was the ordinary boulder-clay of the lowlands, coloured Indian-red by the red rocks of the district; partly a gritty clay, partly a clayey gravel; and containing a great variety of boulders not necessary to name here. A number of the boulders had been finely glaciated atop *in situ*, and some excellent illustrations presented themselves of the

[1] Trans. Cumberland and Westmoreland Assoc., No. ix., 1883-84, p. 169.

fluxion-structure communicated to the till by the heavy drag of the glaciers over it.[1] Here and there were some current-laid seams of sand and gravel; a bed of reddish laminated clay without stones lay in the south-east corner.

The upper surface of this till and clay was even but not level, swelling gently up into a low arch near the middle of the new dock, and shelving rapidly seawards towards the outer extremity of the old one, which (the outer part) was consequently founded on piles. The till, its seams of gravel, and the laminated clay, had been cut clean across before the deposit of the shell bed overlying.

There therefore exists at Silloth that unconformity between the glacial deposits and the post-glacial which seems to characterise their relations throughout the south of Scotland.[2]

The Shell-bed.—The shells that gave to this thin bed its character had lived and died undisturbed where they lay. The common shells, so far as I observed, were the common oyster—sometimes to be seen sticking, along with large barnacles, to the stones, and often much perforated by *Cliona; Pecten opercularis* in various stages of growth; the common cockle and mussel; *Fusus antiquus, Buccinum undatum,* and some specimens of *Littorina littorea* and *Turritella communis. Tapis pullastra* was observed with its valves closed. Here and there stood a boulder of Criffel granite or some other stone richly crusted with corallines (*Lepralia*) and serpulæ. One of the largest of these crusted boulders of Criffel granite (about 1½ foot in diameter) rested on the surface of the stoneless laminated clay. The matrix of this shell-bed was for the most part a bluish fetid-looking mud, much mingled with stones. The large jaw of *Bos primigenius* had manifestly, from its dark-staining, lain upon or among it. The general appearance of the bed was pretty conclusively that of a sea-bottom. Its present position is from 10 to 12 feet above ordinary low-water level. It probably marks the

[1] See Fig. 11 of the writer's paper "On Boulder-Glaciation," p. 181 of this volume.

[2] Crosskey and Robertson; Monograph (Palæontological Society) of the Post-Tertiary Entomostraca; Prof James Geikie, Prehistoric Europe, chap. xvi.

existence of shallow sea placed some distance beyond reach of the deposits of shifting sand which at present occupy the upper part of the Solway Firth.

The Current-bedded Sand and Shingle.—The remainder of the marine deposit was intensely current-bedded from top to bottom. Its shells for the most part were wasted and broken, and scattered about at random. They had evidently been washed to and fro in the ceaseless currents to which the whole bed testified. A valve of *Pholas candida*, found in sand near the bottom, was among the few remains of shell life which had escaped unwasted, probably from its lightness. The other shells were, I think,[1] chiefly mussels and limpets.

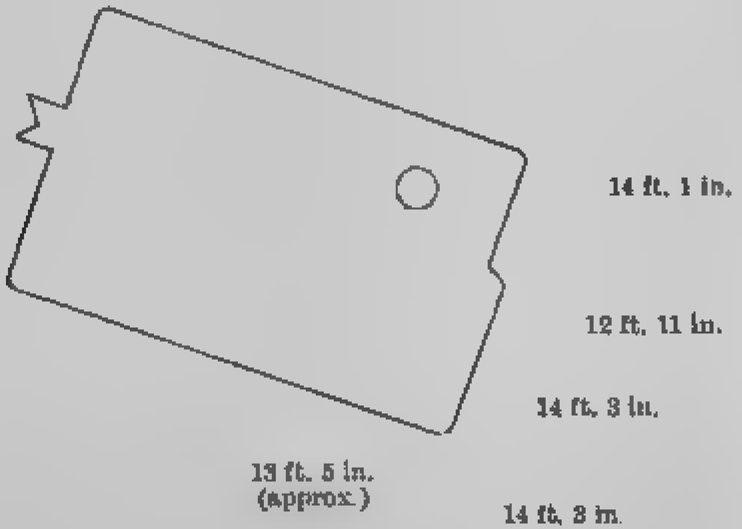
The gravel, like the sand, was inconstant and false-bedded. In parts of the dock it had been laid down in good thick beds as much as ten feet in thickness and of great value to the contractors; but these I observed wedging out into the sand, or dividing up amongst it like the rays of a fan. I had gone to the dock expecting to find a general slope of the bedding seawards—like that of the present beach. There was no such slope: and I may also remark that I failed to detect the general slope *shorewards* which my colleague, Mr Goodchild, seems to have remarked.[2] But in any case the deposit was one mass of current-bedding as if laid down by shifting currents in a waterway. There was not a horizontal layer in the whole. Here and there were lumps and thin layers of current-drifted peat, and a few snags of sodden-looking wood. Towards the bottom there had been much circulation of underground water above the retentive till, and the gravel was rusted and stuck together in masses by a deposit of hydrous peroxide of iron. When I visited the dock the water was still streaming out from the side nearest the town, the wells of which had been partly tapped owing to the continuity of the deposit for some distance inland.

Some of the bones bear the rusty colouring of these lower

[1] I regret that my notes of the shells of the whole deposit are rather meagre. I was informed that large collections were being made by the then curate of Silloth with a view to its elucidation. The lists, however, if they exist, have not been made available for quotation here.

[2] Trans. Cumberland and Westmoreland Assoc., No. ix., 1883-84, p. 214.

ferruginous beds; all of them except the jaw of *Bos primigenius* came from the lower part of this sand-and-shingle deposit. The skull lay at the very bottom, about 28 feet from the surface. The large humerus belonging to the same



Plan of New Dock, Silloth.[1] Scale, 1 inch = 420 feet. Position of the Fossils marked by a circle, within the circumference of which they were probably all found. The figures give the elevation of the top of the marine deposit above the level of ordinary spring tides in feet and inches as determined by theodolite; that on the left is approximate.

species was found about 10 feet higher, or 18 feet from the surface. The large antler of red deer appears to have lain at some yards distance at about the same level; and the smaller one, the first of the bones met with, about a foot higher. All the other bones lay near the red clay, and within a few yards of the skull.[2] One of the cetacean vertebræ was rolled and worn; the other bones were fresh and unwasted.

The upper part of this deposit had been largely removed before I visited the spot. At various points, however, varying from 25 to 35 yards from the edge of the dock, parts of the original surface are still preserved, and my friend Mr J. T. Middleton, one of the contractors, kindly had the levels determined by theodolite whilst I remained on the spot. The surface had been a slightly undulating one. The highest point observed was $14\frac{1}{2}$ feet above the level of ordinary spring

[1] Reduced from a plan on the largest Ordnance Scale communicated by Mr J. T. Middleton. The figures are added.

[2] These particulars are fully given in my friend Dr Leitch's paper (*loc. cit.*, pp. 171, 172).

tides, and 7 or 8 feet above the highest tide recorded at Silloth. The deposit, therefore, belongs entirely to the period of the raised beaches, dating back probably to the elevation of the country from the "50-feet" to the "25-feet" level as recorded in Scotland generally, and certainly not added to since the upheaval of the 10 to 15 feet beach now traceable round the Solway from Scotland into England, and known on both sides of the country. From evidence furnished at the two ends of Hadrian's Wall, it seems indubitable that the North of England has undergone no change of level since the Roman occupation.[1]

Blown Sand.—"When the old dock was made," says Dr Leitch,[2] "and when the lines of railway leading to it, and which, until lately, ran over the site of the new dock, were laid down, several sand dunes, 20 to 30 feet in height, had to be removed." The sand-drift, however, did not cease. Much to the annoyance of the workmen, it even continued more or less throughout the progress of the new dock, and in spite of the precautions of the contractors. The chance cuttings or scoop-shaped slips at the edges of the new excavation were in this way levelled by fresh sand-deposits, and the top section of the dock-cutting assumed much the appearance of *bona fide* blown sand.

My friend, Dr Leitch, to whom I have already had occasion to acknowledge my indebtedness, and who visited the dock

[1] Dr Collingwood Bruce, "Handbook to the Roman Wall," 1884, pp. 38, 222. These facts seem not to be generally known among geologists. I make no apology for quoting Dr Bruce: "Mr Buddle, the famous coal engineer, told the writer that when bathing in the river (the Tyne) as a boy, he had often noticed the foundations of this wall (at Wallsend, on the Tyne) extending far into the stream. Mr Leslie has seen it go as far into the water as the lowest tides enabled him to observe" (p. 38). And again, "At Wallsend we have seen that the eastern wall of the station was continued down the hill to a point below low-water mark in the river Tyne; a similar arrangement prevailed here. Mr M'Lauchlan says, 'Beyond Bowness . . . . the old inhabitants point out, at about 250 yards from the north-west angle of the station, a spot where a quantity of stone was dug out of the beach many years since for building purposes, and the line of it was followed for some distance under the sand without arriving at the end of it'" (p. 222).

[2] *Loc. cit.*, p. 170.

along with my colleague, Mr Goodchild, has thus been led to give the section as consisting of about 8 feet of blown sand, and only about 20 feet of marine deposits. These 8 feet, as it chances, make all the difference between a modern coast deposit and a much more ancient *raised beach.*

Probable Succession of Events as Testified by this Section

The order of events which led to the formation of the deposits thus described may have been somewhat as follows:—

1. The ice age: glacier ice moving heavily over the boulder-clay.

2. Gap, not now represented by any deposit in the section. Formation of the arctic marine deposits of the 100-feet beach of Scotland, and close of the ice age. Denudation, possibly submarine, but more probably resulting from an elevation of the coast, sufficient at least to bring the deposits within range of coast denudation. A few boulders washed from the boulder-clay and left lying on the top.[1] Finally, the country for a time brought to a stand some 40 or 50 feet below present sea-level.

3. Shallow sea 7 or 8 fathoms deep; oyster scalps, etc.; little or no deposit from off-shore.

4. Elevation of the coast to the 25 or 30 feet level; water shallowed; strong currents; a great sea-drift of sand, etc.; carcases of animals, blown up by gases of decomposition floating past and dropping to pieces, and perhaps kept circling in some bight of the shore or little eddy near it; some peat and wood carried to sea from the peat bogs in the interior. Possible oscillations of the coast-line.

5. Elevation into present position some time prior to the Roman occupation. Sand dunes.

[1] In this section there is unfortunately no trace of a land surface nor evidence of the continental forest-epoch of "Pre-historic Europe" except the fact of the unconformity, and the denudation to which it seems to point.

XXVI. *On some Modifications of Recording Apparatus for Physiological Purposes.*

By R. MILNE MURRAY, Esq., M.A., M.B. [Plates XII.-XV.]

(Read 18th February 1885.)

Experimental Physiology depends to such an extent on the graphic method for the record of observations, that it may be said that Recording Apparatus is the first item in the furnishing of the laboratory. Accordingly, physiologists and mechanicians have combined to render such apparatus so complete and so well adapted for all purposes, that it would seem little remains to be done in the way of increasing its efficiency. The Kymographion of Ludwig, and even more so the elaborate system devised by the Cambridge Scientific Instrument Company, are, indeed, so complete and perfect in all details, as to render them undoubtedly capable of meeting all demands which could be made on such apparatus. But this very elaboration and perfection of detail has only been obtained at the expense of much labour and skill, and the construction of the apparatus demands the highest proficiency in workmanship. The consequence is, that the cost of such instruments is very great; and while, of course, there need be no great difficulty in their being provided for a well-endowed laboratory, this cost places them beyond the means of most private workers, and is a serious obstacle to private research. And while we may admit that we must look to the workers in regular laboratories undertaking those inquiries demanding the greater amount of time and application, we need not doubt that there are many points of great physiological interest which may readily be investigated by those who have neither by right nor by favour the command of the resources of a public laboratory. But, on the other hand, such attempts are precluded by reason of the grave initial cost of the apparatus demanded.

With a view, then, of bringing such inquiries more nearly within the limits of private means, I have ventured to describe, in this paper, an apparatus which I have employed for some time, and which I find to answer all purposes of both smoked and continuous paper work.

The recommendation which I claim for this machine is that of cheapness combined with an efficiency which enables it to meet all ordinary demands. I do not mean to suggest that it possesses any advantage over the other forms referred to, other than that it is much cheaper than any with which I am acquainted, and that I have never found it incapable of fulfilling any demand I have had to make on it in the course of an inquiry which has proved, I believe, a fair test of its efficiency.

The essential characters of a good recording apparatus seem to me to be:—

1. That it have a steady motion.
2. That it possess a reasonable variety of speeds.
3. That it can be readily adaptable for both smoked and continuous paper work.

These properties will, I believe, be found in the apparatus I am about to describe.

1. Apparatus for Smoked Paper.

The motive power employed is a strong clock driven by a spring, and capable of running for 15 minutes without re-winding. It can of course be wound without interfering with the running. This part of the apparatus was originally made from drawings by Mr John Shewan, at one time laboratory assistant to Professor Rutherford. It is shown with the drum attached in Pl. XII., Fig. 1. The clock has a train of five wheels, and is supported between two plates 10 in. by $3\frac{1}{2}$ in. The last wheel of the train is bevelled and drives a horizontal spindle, carrying a regulator of very simple construction, and which seems to me to serve all the purposes of the more complex governors usually applied. It is shown in Pl. XII., Fig. 2. The spindle referred to carries a crosspiece of brass having four square eyes, two in each side of the spindle. Into these eyes a short brass wire (square in section) passes on either side. This wire carries at its further end a thin metal plate, 2 in. by 1 in., and moves freely in the eyes. The plates are pulled towards each other by a spiral spring of slender wire, the ends of which are hooked into holes piercing the near sides of the plates.

When the clock starts running, the speed increases, the plates tend to separate, and offer an increased resistance to the air.

Two different speeds can be obtained by means of an interchangeable gearing between the fourth and fifth wheels of the train. By moving a check on the lower clock plate, the arbor of the fourth wheel can be shifted so as to bring a pair of wheels of different diameters into gearing, and thus the speed is increased four times. The arbor of the second wheel is carried 1 in. through the upper plate, and is brought to a quick point. On this fits tightly a circular brass disc $1\frac{1}{2}$ in. in diameter, in such a way as to have the pointed end of the arbor projecting $\frac{1}{8}$ in. This disc has two stout steel pins $\frac{3}{4}$ in. in length, screwed into its upper surface near its margin, and separated from each other by $\frac{1}{8}$ in. The spring is wound from the end opposite the regulator, by means of a key acting on it by a pair of bevelled wheels.

The clock rests on three legs, one under the regulator, and a pair at the opposite end. These latter are continued upwards into two uprights, $3\frac{1}{2}$ in. apart at the base, and $1\frac{1}{2}$ in. at the top, where they are connected by a stout crosspiece. Two cross bars at the lower part of these give a firm connection to the clockwork by means of strong screws. On the piece joining the top of the uprights, a thick arm of brass projects 3 in. over the clockwork, and receives at its further end a pointed steel screw with milled head and running washer. The point of this screw is exactly over the pointed end of the arbor of the second wheel, which carries the brass disc referred to above. The drum is 6 in. in diameter, and $5\frac{1}{2}$ in. deep, and is similar in construction to the drums ordinarily employed. It is provided with a collar and clamping screw at the top, so that it can be fixed at any point on the spindle which carries it.

This spindle is a well-turned steel rod 8 in. in length, and $\frac{4}{10}$ in. thick. It is cupped out at each end, so as to receive the bearing points already described. It is further pierced by a hole $\frac{1}{4}$ in. from the lower end. When in position on the clock, a pin passes through this hole and between the upright steel pins on the disc. Thus, when the clock is started, the spindle is carried round with the disc.

When the pin is withdrawn, the spindle and drum can be rotated in any direction without affecting the clock. The convenience of this arrangement will be apparent when the continuous paper apparatus is described (Pl. XII., Fig. 3). The slow speed gives one revolution in 35 seconds, and the quick one in 8 seconds. The clock is stopped by a simple brake, which acts on a disc carried by the governor spindle. There is also provided a more rigid check, which is useful when the instrument is being moved about. Under such conditions, the light brake referred to might be shaken off, and permit the clock to start. This extra check is of course not required when the clock is being stopped in working, as the brake referred to is amply secure and very convenient.

For smoked tracing requiring such speed as that mentioned, this apparatus will be found quite efficient. It would serve well for demonstrating such experiments as those on muscular contraction, etc. It is compact, works with remarkable regularity, and can be employed in either a vertical or horizontal position.

When, however, a slower rate of motion is required, the apparatus, as described, is of no use; and in order to provide in a simple and economical fashion such a variety of speeds as may be necessary, I have made the arrangement shown in Pl. XIII.

The clockwork already described, from which the drum has been removed, is again employed as the motor. It is now placed on a bracket fixed to the end of the table, and placed about 3 in. lower than the top of the latter. The steel pins in the disc on the second wheel are unscrewed, and the disc itself reversed on the arbor. The disc, which is cut with a groove on its edge, thus forms a pulley. A much smaller disc, also grooved and ¼ in. in diameter, is fixed on what is now its upper surface. We have thus a compound pulley, the larger portion 1½ in., and the smaller ¼ in., in diameter, turning once in 35 or 8 seconds according as the clock is running at its slow or quick speed.

The drum is now arranged on a steel spindle of the same thickness as the former one, but 16 in. in length. This spindle carries near its lower end a compound pulley of three

parts—6 in., $4\frac{1}{2}$ in., and $2\frac{1}{2}$ in. in diameter respectively. This pulley is attached to a collar and pinching-screw, by which it can be fixed at any point on the spindle. The spindle is cupped at both ends, and turns between two bearing-points. The lower one is fixed to the horizontal base of a strong wooden stand, and the upper is borne by a strong brass arm, which projects from the upright part of the stand.

The stand is made of two pieces of thoroughly seasoned mahogany, $1\frac{3}{4}$ in. thick. The upright part measures $12\frac{1}{2}$ in. by $8\frac{1}{2}$ in., and the base is of the same breadth, and 7 in. from before backwards. The two are fastened together by strong screws, and are rendered still more rigid by means of two iron knees.

As already stated, the base carries a bearing-point for the lower end of the spindle. This is fixed to a brass disc, which is screwed down to the wood, and is set 3 in. from the front and the same distance from the right side of the base. This brings the side of the drum to be flush with these sides of the base. The upper bearing is carried by a heavy brass knee, $1\frac{1}{4}$ in. broad and $1\frac{1}{2}$ in. thick, firmly screwed by its perpendicular part to the upright. The horizontal arm carries the pointed bearing-screw. This screw is similar to that in the frame of the clock already described, and is fixed in the same way.

The distance between the two points is $16\frac{1}{2}$ in. This length of spindle enables the drum to be moved considerably more than twice its height in a vertical direction. The pulley on the spindle is adjusted so as to be on a level with the pulley on the clockwork, when the latter is on the bracket at the end of the table. A soft cotton cord, forming an endless band, passes round one or other groove on the pulley of the clock to one of the pulleys on the spindle of the drum; and it will be seen that a considerable variety of speeds can be obtained by changing the cord from one groove to the other. There being three sizes of pulleys on the spindle and two on the drum, we have six different speeds with each speed of the clock, thus giving twelve different speeds by this means. If we include the two speeds available when the drum is driven directly by clockwork, we

have in all fourteen available variations of rate for smoked work. These vary from one revolution in 8 seconds to one revolution in 12 minutes. Were further differences of rate required, they could be obtained by increasing the complexity of the pulleys, but it seems to me that the arrangement described is ample for all purposes.

The motion is exceedingly steady, and the stand can be readily moved on the table so as to adapt it to the recorders, it being only necessary to see that the band is kept reasonably tight. Further, by setting the clock on its end and the stand on its upright, the drum can be made to rotate in a horizontal position. The direction of rotation can also be readily reversed, when vertical or horizontal, by twisting the cord on itself.

2. Apparatus for Continuous Paper.

The Cambridge Scientific Instrument Company supply, at a cheap rate, recording paper in long rolls and of any breadth. Each of these rolls is provided with a wooden core 2 in. in diameter, and pierced by a hole about ½ in. in diameter. Such a roll is fitted on a brass bobbin, the details of which are seen in Pl. XIV., Fig. 2. The bobbin consists of a brass tube a little shorter than the core, and fitting it tightly. This tube is screwed into a hole in a circular brass plate 8 in. in diameter. The whole is set in an upright iron stand of such a thickness as will permit the tube to turn on it readily. The height of the bobbin is regulated by a collar, which can be clamped at any height on the stand. On the top of the core rests a disc, the central portion of which is thicker than the peripheral. The central portion is 1½ in. in diameter, and bears on the core, the thinner part projecting a little over the paper, but not touching it. A bow-shaped spring made of flat steel rests on the disc, and can be forced down so as to press the disc on to the core. A clamp keeps the spring in position. By this means the resistance of the web to its being unwound can be increased or diminished. The end of the paper passes round the drum on the wooden stand already described, which acts as a recording surface, and near which the paper bobbin is placed. From this the paper passes on to a brass bobbin, which is now set on the

clockwork in precisely the same way as was the drum in Pl. XII. This bobbin is $6\frac{1}{2}$ in. in length, 3 in. in diameter, and a flange at its lower end projects 2 in. all round. There is also a narrow flange at the top. The end of the paper is attached to this bobbin by a little gum, and on the clock being started the paper is wound on to the bobbin, passing in a steady fashion over the drum, which turns with it, and forms an excellent recording surface.

This simple arrangement, by which the paper is wound up as it passes the pens, instead of running out on the table or floor as it does in some other forms of continuous apparatus, is, I take it, a considerable advantage. In the latter case the paper gets much in the way, and is apt to be torn when it comes to be rolled up or examined, the coils frequently getting mixed up. The only objection to the system that I can conceive is, that the rate of motion past the recorders will increase slightly as the bobbin gets filled, but this is of course readily checked by the time markers. Should it be desired, however, to have the paper running out without being wound up, a pair of friction rollers can be pressed on to the bobbin, and the paper run out in the ordinary way. The attachments for these rollers are seen to the left upright on the clock frame, Pl. XIII.

When the paper is to be removed from the bobbin, the web is cut through, the clock turned on its end, and the pin withdrawn from the lower end of the spindle. In this way the paper can be unwound and rolled or folded into lengths as may be convenient.

The entire apparatus can be made by Messrs H. & J. Millar, clockmakers, Castle Bank Works, for something under £10.

3. Time Marker.

When long tracings are being taken, the attention demanded in order to keep the pens supplied with ink is often considerable. With the view of reducing this somewhat, I venture to describe an arrangement of time-marking pens which I have found exceedingly convenient.

The idea is a modification of the neat time-marker of the Cambridge Scientific Instrument Company, and is, I believe,

adopted by them since I suggested it some time ago. The arrangement is seen in Pl. XV., Fig. 1. The small electro-magnet is fixed on a brass plate, and draws down an armature carried by one end of the short lever. This is pulled away again by a spiral spring seen in front of the pillar. The other end of the lever ends in a binding screw, through which passes a thin wire about 3 in. long. This wire is bent at its further end in the way seen in the figure, and serves as the means of attachment of a piece of fine vaccine tube bent at right angles, the point of the horizontal half of which presses on the paper. The vertical arm of the tube dips into a brass cup carried at the end of another wire which passes through a hole in the pillar, in which it is secured by a pinching screw. This cup is filled with ink, which flows by capillarity along the tube, and runs steadily out on the moving paper. The most convenient way of fixing the vaccine tube to the wire is by means of one or two turns of fine silver suture wire. If thread is employed it is apt to tighten when wet, and often snaps the tube. Such an arrangement will work continuously for many hours with no further trouble than the occasional supply of a few drops of ink to the cup. If smoked paper is to be used, it is only necessary to remove the cup and ink tube and attach a wire carrying a sharp writing point to the binding screw on the lever.

4. Laboratory Clock.

I have had a simple form of laboratory clock constructed which has proved satisfactory and convenient.

The clock is driven by a spring acting on a train through a fusee, and is thus regular for all states of the spring. The pendulum is a half-seconds one, and the dial is divided into thirty divisions, and is traversed by the pointer once in fifteen seconds—one division corresponding to half a second.

Across the frame of the clock, behind the works, a narrow wooden bar is fixed, through a slot in which the pendulum rod swings (Pl. XV., Fig. 2). The rod is of brass, and carries a brass block at its middle point, the lateral surfaces of which are covered with platinum. On each side of the slot a brass pillar carries in a vertical position an exceedingly

light French clock pendulum suspension. Each suspension is pierced by a fine screw tipped with platinum. These screws are so adjusted as just to touch the surface of the block at each swing of the pendulum. One pole of a bichrome battery is connected to the works of the clock. The current, passing down the pendulum, passes along the screw in contact and on to the time-marker, with one end of the magnet of which the screws are connected. The other end of the magnet is connected to the other pole of the battery.

The contacts are in metallic connection by wires leading to a binding screw on the side of the clock. But a key interposed can be employed to break the circuit, in which case the pendulum only makes circuit on one side of its swing. Thus it will send second-signals to the marker; when both are connected, half-second signals will be sent. The connections are obvious from the diagram.

It is often necessary to keep accurate record of periods of the time during which an observation is to be made. Periods of five minutes or upwards can be readily noted from a watch or ordinary clock with sufficient accuracy, but shorter periods of a minute or less cannot be so readily observed without the aid of a special assistant. To provide for this, I have made an addition to the clock referred to, which answers the purpose well.

To the end of the arbor of the scape wheel in the clock just described, a small steel claw is fixed, which will thus revolve once in fifteen seconds. At one point of its revolution it touches and closes a platman contact carried on a light steel spring. This momentary contact serves to energise a small electric bell connected with it, and placed on the experimental table. Thus every period of fifteen seconds is indicated by a stroke of the bell. Another wheel of the train makes one revolution in two minutes, and a similar contact is adapted to its arbor, and communicates with the magnet of another but larger bell set on the same stand. By counting the strokes of the two bells, periods of time from fifteen seconds and upwards can be readily noted without lifting the eyes from the table. This clock is made by Mr Bryson, George IV. Bridge.

5. Automatic Key.

Fig. 3, Pl. XV., shows a simple key which can be employed as an automatic make or break key. It is fixed to the upper plate of the clockwork (Pl. XII., Fig. 1) by an adjustable clamp seen in the figure. It is set so that the arm projecting up from the bar of the key is just touched by a light steel spring which can be adjusted to the lower end of the drum, but which is not shown. If the wires are attached at the binding screws on the right, the current will flow through the key when in the position shown. As the point of the drum referred to comes round, it touches the arm, throws over the key, and breaks the current. On the other hand, if the wires are connected to the screws on the left, no current will flow with the key in the position shown, but when turned over by the drum, circuit will be made by the left contact dropping into the mercury cup.

XXVII. *Remarks on the Ovary of* Echidna. By Frank E. Beddard, Esq., M.A., F.R.S.E., F.Z.S., Prosector to the Zoological Society of London. [Plates XVI., XVII.]

(Read 21st January 1885.)

During the past year the re-discovery by Mr Caldwell of the long-forgotten fact that the two representatives of the order Monotremata are oviparous, has attracted considerable attention to the group, and, as a result, a number of communications on the subject have appeared in various journals, scientific and otherwise. More particularly to be noticed are two reviews—one in *Nature*,[1] by Mr Baldwin Spencer, and another in *Science*,[2] by Mr J. Gill—which give an account of all the observations concerning the eggs of the Monotremata that had been made previously to Caldwell's telegram to the British Association at Montreal. It appears that Fleming, in his "Philosophy of Zoology" (ii., p. 215), which was published so long ago as 1822, was the first to call attention

[1] December 11, 1884. [2] December 1884.

to the fact that these mammals lay eggs; he stated that specimens of the eggs had been sent to London. A few years later (1829) Geoffroy St Hilaire communicated a paper to the French Academy upon the same subject. This naturalist described and figured the egg of *Ornithorhynchus*, and made use of this fact in its life-history as an additional argument against including the Monotremata among the Mammalia. It was the opinion of Geoffroy St Hilaire and also of Lamarck that the Monotremata should form a distinct class of the Vertebrata, equivalent to, and not included in, the Mammalia.

I need not recapitulate here the numerous other papers and notices respecting the eggs of the Monotremata, but refer the reader to Mr Spencer's review for further details on the subject. There are several papers, however, which have appeared since, and have not therefore been referred to in the review from which I have quoted. One of them is by Sir Richard Owen, who has re-described[1] and figured the generative organs of a female example of the Australian Ant-eater; both the uteri of this specimen contained a "collapsed ovum," which was shown to be entirely unconnected with the walls of the uterus.

A recent number of the *Zoologischer Anzeiger*[2] contains a paper, by Dr W. Haacke, on the ova of *Echidna*, and the same gentleman, on Thursday, January 8, communicated an account of the discovery of this fact, together with observations on the pouch and the mammary glands of the male, to the Royal Society of London, which are not, of course, published as yet. In the paper in the *Zoologischer Anzeiger*, Dr Haacke describes having found an egg in the pouch of an *Echidna* "about 2 mm. long, and having a shell, as in many reptiles, of a parchment-like consistency."

Mr Caldwell's telegram to the British Association contained another statement, and one of greater importance—viz., that the ova of the Monotremata are meroblastic; and this is the real essence of the discovery. Unlike what is found in other mammalia, the ova of the Monotremata only undergo partial segmentation. The large ovum is furnished

[1] Ann. and Mag. Nat. Hist., Dec. 1884.

[2] Jahrg. vii., No. 182, Dec. 1884.

with abundant yolk, and the process of cell division is confined to a protoplasmic germinal disc, and does not include the yolk. The early developmental stages of the Monotremata therefore are necessarily similar to the corresponding stages in the development of the Sauropsida, and so far dissimilar to the other groups of the Mammalia. This fact has *perhaps*, as has been suggested, some bearing upon the origin of the Mammalia, as tending to show that they have been the offspring of Sauropsidan-like ancestors, and have not been derived, as has hitherto been believed, from a group more closely resembling the existing Amphibia, inasmuch as the ova of the latter group undergo total segmentation. It is obvious, however, that this deduction may be questioned, and no doubt Mr Caldwell will be able to furnish more evidence on the point from a study of the whole course of development of the Monotremata.

With regard to the partial segmentation of the ova of the Monotremata, it appears to me to be just to remind the Society that my friend Mr E. B. Poulton had previously described the structure of the ovarian ovum of *Ornithorhynchus*, and to some extent of *Echidna*, and that his results had rendered it extremely probable "that segmentation is unequal, perhaps partial." This does not, of course, detract from the merit of Mr Caldwell's discovery, who independently proved to be a certainty what Mr Poulton could naturally only regard as a probability.

In a very interesting paper recently published in the *Quarterly Journal of Microscopical Science*,[1] and already cited, Mr E. B. Poulton has described the structure of the ovarian ovum of *Ornithorhynchus* and *Echidna*, more particularly the former. The result of his investigations has been to show that in the Monotremata the ovum occupies the whole of the follicle, and that the epithelium of the follicle remains a single layer during the whole time that the ovum is enclosed within it. This result is clearly a very important one, inasmuch as it indicates a close resemblance to the conditions met with in the ovary of the lower Vertebrata, and a considerable difference from the same structures in the Mam-

[1] Quart. Jour. Micr. Sci., January 1884.

malia, where the follicular epithelium surrounding the fully-developed ova is always composed of a great number of layers of cells, which form a specially dense accumulation in the region of the ovum, the so-called *discus proligerus*, the rest of the Graaffian follicle being filled with fluid. It is only during the earlier stages of the development of the ovum in the mammalian ovary that the follicular epithelium consists of but a single layer of columnar cells. These facts are well illustrated by several figures, which represent the ova and portions of the ovary of *Ornithorhynchus.*

The opportunity of carefully preserving the ovaries of *Echidna* for histological study has been afforded me by the recent death of a specimen in the Zoological Society's Gardens, and I think it worth while to publish my results, since they are, to some extent, fuller than those of Mr Poulton (who had only comparatively poor materials to work at), though in regard to the important fact relative to the structure of the follicle I can only confirm the accuracy of his account.

Mr Poulton's description of the ovary of *Echidna* is as follows: "The condition of the ovaries of *Echidna* was such that I could make out nothing except the important fact that the follicular epithelium and zona pellucida are similar to *Ornithorhynchus.*" Although this sentence contains a correct statement of two of the most important facts in the constitution of the ovum and follicular epithelium of *Echidna*, the matter appears to me to be worth going into in further detail, and that I have attempted to do in the present paper.

The epithelium covering the ovaries externally consists of a single layer of columnar cells, the size of which is not absolutely uniform over the whole organ; in certain regions the cells are considerably taller than in other regions. The follicular epithelium of the ovarian follicles shows a greater resemblance to the outer columnar epithelium of the ovary in the character of the cells which form it; and this fact is not remarkable, since it is well known[1] that the follicular

[1] This is a point on which opinions differ. Dr Foulis believes that the follicular epithelium is a derivation of the ovarian stroma. The most recent edition of Quain's "Anatomy" (ninth edition) appears to favour the view given in the text.

epithelium, as well as the ovum, is derived from the outer columnar epithelium of the ovary. But what *is* remarkable is that the follicular cells, during the earliest stages of the development of the ovum, are flattened and quite different in appearance from what they presently become, as well as different from the cells whence they are derived. The columnar epithelium was frequently distinguishable by having become less deep stained by Borax carmine than the subjacent tissues. Beneath the columnar epithelium is the ovarian stroma, which does not appear to present any great difference from the same tissue in other Mammalia. The outer layer of the stroma—that containing the ovarian follicles in various stages of development—is a more compact tissue, and not nearly so vascular as the central core of the ovary, which, in all the sections examined by me, was filled with numerous large blood-vessels, which were extremely conspicuous through having in most cases retained their fluid contents. In the outer part of the ovary but few blood-vessels were observable, except in the immediate neighbourhood of the ova. The central tissue of the ovary is also remarkable for the abundant presence of roundish cells arranged in groups and strings, and largely filled with a yellowish matter of a fatty appearance. These are presumably the remnants of the Wolffian tubules.

The immature ova are invariably, as would naturally be expected, placed close to the surface of the ovary; they are surrounded by a follicular epithelium only one cell deep, the cells of which, as already stated, are not columnar, but appear more or less oval both in transverse section and in superficial view. The vitelline membrane is no doubt present, but it is so thin that I was unable to recognise it in any case, and the number of sections I have studied is very considerable; on the other hand, the basement membrane of the epithelium was extremely conspicuous. The stroma of the ovary, which in the cortical region is more cellular, being composed of a compact mass of oval to fusiform cells, becomes distinctly fibrous in the neighbourhood of the ova, forming thus a special sheath for them (see Pl. XVII., Fig. 6). The germinal vesicle is of considerable size, and separated by

a distinct wall from the surrounding substance of the ovum; as a rule it appears to be eccentric in position even in the youngest ova, though occasionally it is nearer to the centre. The contents of the germinal vesicle present the appearance of being fluid or semifluid; in most cases its substance had shrunk away from the wall, and filled only half the space.

In ova about twice the size of those just described, and figured in Pl. XVII., Fig. 6, the vitelline membrane appears as an obvious limiting membrane of the ovum. In a more mature ovum, such as that figured on Pl. XVII., Fig. 7, the following structures can be easily recognised: The ovum is bounded externally by a stoutish homogeneous membrane (*m*), which stains deeply with Borax carmine; this appears to be the *zona pellucida*. It is about half the diameter of the follicular epithelium (*f*), from which it is naturally sharply marked off as from the subjacent yolk. Generally speaking, however, the ovum, when it shrinks away from the wall of its follicle, carries the follicular epithelium with it. The *zona pellucida* appears to me to be the only egg membrane in *Echidna*. I did not succeed in recognising any of the subjacent layers figured and described by Mr Poulton in *Ornithorhynchus*; only the central portion of the membrane presented the appearance of a greater density than the outer and inner layers, and in the sections studied by me was somewhat more deeply tinged by the staining re-agent. I am not at all clear, however, that this was not an optical delusion caused by the displacement of the follicular cells, or the crumpling of the *zona pellucida* itself, inasmuch as I was unable to trace the darker band round the whole circumference of the ovum, and I only occasionally noticed its presence. Immediately beneath the *zona pellucida* is a layer of finely granular yolk, the extent of which is about equal to the diameter of the follicular epithelium and the *zona pellucida* taken together; this peripheral layer of the yolk is hardly at all affected by Borax carmine. The main portion of the ovum is made up of a protoplasmic reticulum, indicated by the blacker lines on Fig. 7, which becomes very deeply stained by Borax carmine, and in successful preparations is for this reason extremely obvious. The meshes of

this network, which, as shown in the figure, are not of uniform size, but vary somewhat, enclose the yolk "cells;" the latter are aggregations of minute spherules, or consist of a single drop of fat which occupies the whole space. Intermediate stages between these two conditions are observable as may be seen from the figure, and also from Fig. 5, which represents a portion of the network much more highly magnified.

The section, of which Fig. 7 is an illustration, was one of a fortunately complete series through a large ovum rather more than 1 mm. in diameter; I have been able therefore to note the structure and position of the germinal vesicle. In my sections the germinal vesicle (*g.v.*) was conspicuous through having been well stained by the Borax carmine; it is situated eccentrically apparently at the junction of the peripheral homogeneous part of the yolk with the central portion, but chiefly in the latter; it is bounded by a distinct membrane; the germinal spot (*g.s.*) was also conspicuous, and situated again eccentrically within the germinal vesicle. The substance of which the germinal vesicle is composed has the appearance of a fluid or semifluid material, which has become coagulated by the re-agents used in the hardening of the tissue. I could see no network; the outer part of the germinal vesicle was rather more deeply stained than the inner portion.

The largest ovarian ova of *Echidna,* measuring up to three millimetres in diameter, appeared to consist of hardly anything more than a mass of yolk spherules closely aggregated together, so much so that in many cases they had become more or less hexagonal owing to mutual pressure. The size of the yolk granules varies pretty considerably, and the accompanying figure (Pl. XVII., Fig. 4), which represents a portion only of such an ovum as that which is at present being described, illustrates this point: *a*, are the larger granules, which are generally circular, but in some cases have assumed an angular contour through pressure; among these may be seen a number of smaller granules (*b*); here and there is an area distinguished by being composed of only small granules; the yolk spherules have in part fused together to form largish irregular-shaped masses (*c*), but this may easily be a *post-mortem* change.

I was able to examine a complete (or nearly complete) series through an ovum of this size, and I failed to observe any trace of an egg-membrane or follicular epithelium. As shown in the figure, the ovum appears to be contained within a capsule formed of a specially thickened layer of the ovarian stroma. It does not, however, seem likely that both the vitelline membrane and the follicular epithelium would disappear in this way; and, unfortunately, I could not examine any ova intermediate in size between this stage and ova of 1 mm. or less in diameter like that figured on Pl. XVII., Fig. 7.

Formation of Corpora lutea.—My observations on the formation of the *corpora lutea* differ somewhat from those of Mr Poulton for *Ornithorhynchus.* The fibrous layer of the follicle becomes very thick, and the follicle itself becomes filled with a homogeneous-looking mass (Pl. XVII., Fig. 1*b*), which stains readily with Borax carmine; *trabeculæ* of the fibrous tissue outside the follicle grow into it, and gradually obliterate the cavity; the mass in the centre of the follicle does not disappear for a considerable time, but remains divided into a number of fragments by the trabecular outgrowth of the follicular wall. The peculiar yellow cells (*a*) appear in the interior of the *trabeculæ,* and increase in number, finally occupying the whole of the follicle. The appearance of the yellow cells which constitute the *corpus luteum* at its last stage of degeneration is extremely like that of the cells which are supposed to be the remains of the Wolffian tubules.

The results contained in this paper show that in every essential point in the structure of the ovum and its follicle, *Echidna* agrees with *Ornithorhynchus,* as described by Mr Poulton. They may be briefly stated as follows:

(1.) The follicular epithelium continues to invest the ovum throughout its sojourn in the Graaffian follicle as a single layer of cells only,[1] as in the lower Vertebrata.

[1] I am not quite certain as to this point. In the large ovum figured on Plate XVII., Fig. 7, I have indicated two rows of follicular cells, and occasionally there appeared to be three. Two or three layers of follicular cells are found in the ovarian ova of birds, and I am therefore inclined to think my observations are correct and not based upon defective preparations.

(2.) The ovum completely fills up the follicle.

(3.) The mature ovum is of immense size compared with that of other mammals.

(4.) The ovum is invested externally by a single membrane, which has a more or less laminated structure, and corresponds to the vitelline membrane; there is no *zona radiata* present at any period (?). The vitelline membrane atrophies or becomes extremely thin when the ovum has attained maturity.

(5.) The contents of the ovum are differentiated into a finely granular peripheral layer, and a central portion consists of larger and smaller yolk spherules enclosed in the meshes of a fine protoplasmic network.

(6.) The germinal vesicle, with its germinal spot, lies eccentrically, within the peripheral layer.

Explanation of Plates.

PLATE XVI.

Transverse section through a portion of the ovary of *Echidna*, magnified about 18 diameters to show the relative size of ova in their different stages of development: *a, b, c,* ova in various stages of development; *d,* ovarian stroma; *e,* blood-vessel.

PLATE XVII.

f = Follicular epithelium.
m = Egg membrane.
g.v. = Germinal vesicle.

Fig. 1. *Corpus luteum.* *a,* yellow cells; *b,* coagulum.

Figs. 2, 3, 6, 7. Ova in various stages of development. In Fig. 7 most of the yolk spherules are represented as having been removed.

Fig. 4. A portion of a large ovum measuring 2 mm. in diameter indicated on Plate 1*b*; *a, b, c,* yolk spherules.

Fig. 5. Portion of ovum (Fig. 7) more highly magnified, to show the protoplasmic reticulum enclosing the yolk spherules.

Fig. 8. Portion of the germinal epithelium, egg membrane, and yolk of ovum (Fig. 7).

XXVIII. *On Reproduction of Lost Parts and Abnormality.* By Professor DUNS, D.D., F.R.S.E., President.

(Read 15th April 1885.)

We are as yet far short of data sufficient to warrant a philosophy of zoology within which to find a fit place for the forms referred to in the title. But there are abundant materials ever at hand for the exercise of the philosophic spirit, in showing that this branch of science is far more than a technical representation of parts and their dependencies—more than mere *scientia rerum.* It is the "*scientia rerum cum causis,*" a favourite dictum of the old workers in another department. Among the good things of Darwinism is the prominence it gives to the thoughts which underlie things, and the conviction it works in those who read it rightly, that this thought is as real as the things, and both as real as the thinker. Thus inferences are as reliable as the data which warrant them, and both are equally abiding. We all feel the temptation to be satisfied with phenomena, but, in the measure in which we yield, we fall short of our work, and become biological hodmen, handling the parts of which the house of life is built, but discerning not purpose or prevision of any sort in protozoan or in mammal which it is to lodge. Yet the purpose is as real and true, I had almost said, substantial, as the albumenoid mass of the one, or the complicated organs, inter-dependencies of organs, and their parts, of the other. It would be an insult to the botanist to say that the only difference between his estimate of a primrose and that of "Peter Bell," is, that while to the latter it "a yellow primrose was to him and nothing more," to the former it was *Primula vulgaris,* or perhaps *P. vulgaris, varietas acaulis!* It is, however, possible to fail to recognise, and to make nothing of the persistent working towards individualism of that one life-force which, while preserving unity, finds room within it for untold variety, and which gives root and leaf and flower and colour, and utilises air and sunlight, dew and rain, cold and heat.

I make these general remarks chiefly to indicate that it is

to the feeling underlying them, that we are indebted for some of the most important contributions towards a philosophy of zoology. Thus Cuvier's "theory of correlation" of parts of structure and form, Étienne Geoffroy St Hilaire's "theory of connections" of identical parts in identical relations, and Von Baer's embryological types. É. G. St Hilaire's theory was urged by him as truer to nature than that of Cuvier. But, however interesting an analysis of the two schemes and a discussion on the merits of the controversy might be, they would be out of place here. I refer to the controversy because it early led to a most important question—"What are we to make of these wide divergences from normal structure and even from specific features which occur within all zoological classes?" The desire to answer this gave the doctrine of Abnormalities or *Teratology*, and led to the more recent attempt to account for these, or the doctrine of *Teratogenie*. The classical work on the former is St Hilaire's "Histoire General et Particulaire de L'Organisation chez L'Homme et Les Animaux"—three volumes and Atlas, Paris 1832; and that on the latter is M. Camille Dareste's "Recherches sur la Production Artificielle de Monstrosités"—one volume 8vo, with illustrations, Paris 1877. M. Dareste has also published many separate papers on the same subject. St Hilaire's theory was virtually the full restatement of another which has ever been attractive to a large school of French workers, "the chain of beings" theory—*La Chaine des Etres*—with an ability and scientific setting, however, never before associated with it. But abnormalities seemed to break the series. They were apparently outside of law and the contradiction of order. The whole question of antecedent purpose was raised and discussed, and another so-called principle was urged as the explanation of all instances of abnormal structure. Thus a place was found for monstrosities within his "theory of connections" under what he called "the equivalence of organs." If growth was abnormal in excess in one organ, it was the same in defect in another. Perhaps the scientific terms in which these views were stated, and the multitude of scientific facts referred to as illustrative proofs, gave an importance to them which they did not

deserve. At least, few will now give them the high place they once held in biology. Science seems to me to lead to the very edge of an explanation, but I doubt if it can ever go farther. Dareste's object is to show how abnormalities can be artificially produced, with the view, evidently, of suggesting that the cause being known might lead to prevention if not to cure. While both authors use the term "abnormal," both equally question its appropriateness, and desire to bring all the phenomena to which it points into natural lines.

I have associated the reproduction of lost parts with the occurrence of abnormalities, because both point to characteristic features of the one life, in conditions unfavourable to its natural growth and expression, and also because the injuries which make reproduction necessary, may, and often do, lead to abnormal forms. (This was illustrated by the exhibition of the pastern and coffin bones of the horse in an abnormal condition.)

The phenomena of reproduction of lost parts are met with in all the classes, both of invertebrate and vertebrate animals, and point to phases of success in the effort to overcome hindrances to living, not, perhaps, sufficiently appreciated. To indicate the wide range within which instances of reproduction of parts occurs, I need only mention that examples under *Hydridæ*, *Holothuridæ*, *Asteridæ*, and *Canceridæ*, among invertebrates, have come under my own observation. As to the last named, there is an exceedingly able and interesting paper on its occurrence among common crabs, by Harry D. Goodsir (printed in volume ii. of "Anatomical Memoirs of J. Goodsir," edited by Turner and Lonsdale). Goodsir shows that if the phalange of the leg of the common crab be injured, the animal at once throws off the remaining parts of the limb close to the body. By which act, as he proves, it both saves the loss of blood and lays bare the organ which is to reproduce the lost limb.

As to fishes, Gunther has pointed out ("Study of Fishes," p. 188, 1880) that the power of reproduction of lost parts in the *Teleostei* is limited to the delicate terminations of their fin-rays, and the various tegumentary filaments with which

some are provided. In *Dipnoi*, as *Ceratodus* and *Protopterus*, the terminal portion of the tail is reproduced, but without the notochord. Dr Traquair has, however, shown from two specimens of *Protopterus annectans*, that the restoration of the tail carried with it the restoration of the notochord also. In the same paper, read at the Edinburgh Meeting of the British Association, 1871, it was stated that the neural and hæmal arches, spines, and fin-supports were restored, these elements, however, remaining entirely cartilaginous. But, as regards the restoration of injured fins, there are many exceptions. For example, Sir William Jardine refers, in the *Edinburgh Philosophical Journal* for 1856, to the case of salmon which were marked as "parrs" by cutting off their small thick dorsal fin, and this served to mark the individuals till the "grilse" state. The wound made by marking became covered with skin, and in some of the specimens a coating of scales had partly formed. In addition to the parts already mentioned, the cephalic tentacles of the fishing frog (*Lophius piscatorius*) are very frequently injured, and as frequently reproduced.

But, perhaps, it is among the Reptilia that we meet with the most numerous instances of waste and repair, loss and reproduction of organs. When characterising the Water Salamanders, Van der Hoeven, referring to the observations of Blumenbach and Bonnet, says their "reproductive power is very great: in these not only the tail and legs that have been removed grow again, but the eye also can be restored, if only the entire ball as far as the optic nerve be not cut away" ("Handbook," vol. ii., p. 234). Gunther has shown that the tail of the tadpole, if cut off early, will be reproduced before the time when its absorption normally begins, and if a hind limb be cut off when the larva is about two lines long it is reproduced.

One of the three lizards (*Tiliqua Fernandi*) now on the table supplies an exceedingly good instance of a bifid or bifurcate tail. The forks are nearly equal in thickness and in length. The whole length of the specimen is $9\frac{3}{8}$ in. from snout to end of the forks. The break has been made at the first caudal vertebra, if we may judge from external

marks. In this case $\frac{7}{8}$ths of an inch of bone had been added in the process of reproduction. Owen says, "no instance of the restored tail shows ossified vertebræ." It is thus not unlikely that the external marks of break may be in the integument alone. This might have been shown under dissection, but I was unwilling to interfere with the specimen before showing it to the Society. In the same way also it might have been ascertained whether we have in both forks, severally, proportional distribution of the extensor and flexor muscles of the tail. The tendency to divide can be seen over $1\frac{3}{8}$ in. before it takes place, and the free forks are $1\frac{1}{2}$ in. in length; the whole length of the abnormal tail will thus be $1\frac{7}{8}$ in. Another specimen is shown, which also bears marks of injury; but if this is also an instance of reproduction, there has been no tendency to divide. The tail is symmetrical, though not of the normal length, and, as ascertained by probing, the ossified vertebra are present. The third specimen bears clear marks of break, but the example seems one of repair and not reproduction, for the tail is of the usual length and the vertebræ entire throughout. All the specimens were obtained from Old Calabar.

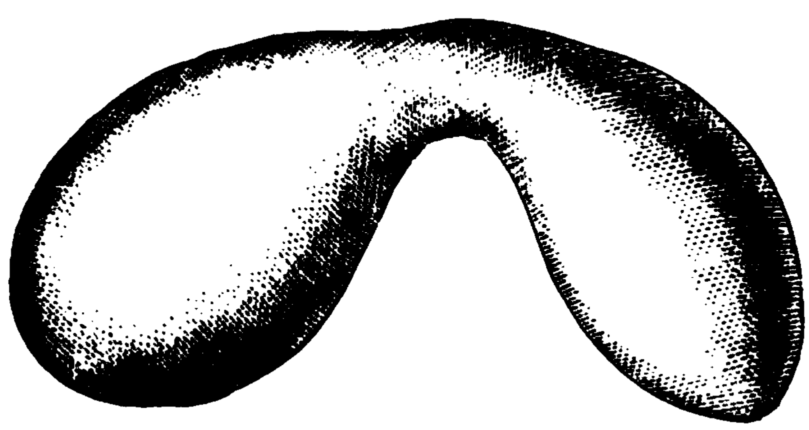
Reference has already been made to the frequent occurrence of the loss of parts among the reptilia. This may at once be seen by taking the order *Sauria* and glancing over any work on regional representatives of the order, as, say Gunther's "Reptilia of British India" (Ray Society, 1864). Such notices as the following occur: Acontiadidæ; *Nessiaburtoni*—tail elongate, generally shorter than the body from its being constantly broken off and reproduced. Geckotidæ; *Gecko*—tail generally verticillated, and breaks off so readily, that the slightest fear will make them shake off their tails. When the tail is reproduced it is rounder and thicker. *Hemidactylus maculatus*—tail more rounded than before it was broken off. *Eublepharis*—tail fragile and easily reproduced. It is worth noting, however, that as to *Draco*, Gunther says—"We have never seen a Dragon in which the tail had been reproduced, nor, indeed, with this member mutilated. Perhaps the tail is necessary for their peculiar locomotion."

I had intended to refer to reproduction of lost parts

among birds, but must pass from this in the meantime. Its occurrence among mammals, and especially in the case of man, is well marked, though comparatively rare. This is a wide subject, and might be very fully illustrated, but I content myself by simply recalling the attention of some of our young anatomists to a paper by Goodsir, read to the Medico-Chirurgical Society in 1844, and printed in his "Anatomical Memoirs." The question discussed arose out of a paper communicated by Professor Syme to the Royal Society of Edinburgh, and published in vol. xiv. of its *Transactions.* Syme asked "whether the periosteum or membrane that covers the surface of the bones, possesses the power of forming new osseous substance independently of any assistance from the bone itself?" There are some things in Goodsir's answer to Syme fitted to shed light on the controversy between Busch and Wolff as to the laws of ossification, referred to in the *Proceedings* of the Physiological Society of Berlin, as reported in last number of *Nature.* I am not going into the merits as between Syme and Goodsir. They were full of interest to me at the time, and linked into some of the studies of my own college days, and they are full of interest still. But I notice them for the sole purpose of pointing to an instance of reproduction in the long bones, the radius for example. Goodsir says—"In no instance do we ever see a new shaft without at the same time observing portions of the old shaft ulcerated to a greater or less extent—the ulcerated portions invariably corresponding in the early stages to the scales of new bone in the periosteum. Whenever the old shaft is entire its periosteal surface presenting the natural appearance of macerated bone, the part corresponding to this in the new shaft is formed of bone, which is seen shooting in the manner peculiar to this mode of regeneration from a point corresponding to an ulcerated portion of the old shaft." He adds—"The new bone shoots in stalactilic masses in the longitudinal direction, their course, direction, and magnitude corresponding to the forms of the rings or portions of ulcerated bone in the old shaft."

It was my intention to refer somewhat fully to specimens of abnormal forms preserved in the New College Museum,

with the view mainly of trying to ascertain whether St Hilaire's theory of "equivalence of organs" affords any satisfactory explanation of these, or any restful point from which they may be considered. I may, perhaps, return to the subject, but at present I wish only to show to the Society two instances—one in the eggs of the Class birds where abnormal growth generally begins, and the other in the case of a kitten. The former consists of two imperfectly developed eggs of the barn door fowl, in which the shells are organically united, a comparatively wide communication



admitting of the contact of the germinal masses, formative and nutritive. The abnormality of the latter consists in the presence of eight legs, four in the natural position, and four on the back. This instance certainly lies outside of the hypothesis of "equivalence!"

XXIX. *Notes on the Structure of a New Species of Earthworm belonging to the Genus* Acanthodrilus (*E. P.*). By FRANK E. BEDDARD, Esq., M.A., F.Z.S.

(Read 15th April 1885.)

About a year since I received, through the kindness of the Rev. G. R. Fisk, C.M.Z.S., of Cape Town, a box containing a number of living earthworms. One of these has been already described by me in a paper read before the Zoological Society of London, which has not yet been published. In addition to this specimen—a large worm of 4 or 5 ft. in length —there were a number of other, considerably smaller, earth-

worms, which proved on examination to belong to two distinct species. One was a *Lumbricus*, presenting no marked differences from our British *Lumbricus terrestris;* and the other a new species of the genus *Acanthodrilus.*

As the Cape of Good Hope is a new locality for this genus, I have thought it worth while to offer to the Society a few notes upon the structure of the species which I propose to name *Acanthodrilus capensis.* The pressure of other work has prevented me from treating of its anatomy in a detailed fashion, but the following notes will, I hope, be not without value from a zoological point of view.

The anatomy of earthworms has at present been but little studied; but we are already acquainted with the fact that these animals present a most remarkable diversity of internal structure, coupled with a very general uniformity in external characters; and it is sufficiently evident that there is an absolute necessity for dissecting an earthworm in order to define at all correctly the species or even the genus to which it belongs. The necessity for accompanying purely descriptive work with anatomical details is perhaps more obvious in this group of the animal kingdom than in any other. The published records of new species and genera of other groups—for example, the Crustacea—which merely relate to external form, are of the greatest possible use, from a zoological or faunistic point of view. Of new species and genera of earthworms, such records are simply valueless, and any one who has studied the anatomy of this group must be well aware of the impossibility in many cases of verifying such descriptions. The species which I shall describe in the present paper clearly belongs to the genus *Acanthodrilus* of Perrier, but it may also very possibly be referred to either of the two genera—*Alyattes* or *Eurydame* of Kinberg. This naturalist has defined his genera by the varying distribution of the setæ; and the last-mentioned genera agree to differ from the others of his system in that the setæ are arranged in four series of pairs in the anterior region of the body, but in eight longitudinal rows in the posterior section of the body, the two setæ of each pair becoming here separated from each other. As a single instance of the impossibility of such a

system, I may refer to this very genus *Acanthodrilus*. In several species the setæ are in four series of pairs equidistant from each other, as in *Lumbricus;* in others the setæ are arranged throughout the body in eight series; while in *A. capensis*, as already stated, the disposition of the setæ is intermediate in character. It must be remembered, of course, that all these species agree with each other in their internal structure so closely, that it is quite impossible to regard them as belonging to different genera; and if the distribution of the setæ were to be regarded as an indication of specific difference and resemblance, certain species of *Acanthodrilus* would have to be placed within the same genus as *Lumbricus*, and separated from their immediate allies.

I have also in this paper recorded for the first time the position of the ovaries and their ducts, which have not as yet been seen in any *Acanthodrilus*.

Another fact of some interest from the point of view of the comparative anatomy of earthworms, is the structure of the body wall. The remarkable arrangement of the longitudinal muscles in *Lumbricus* was first thoroughly made known by Claparède's elaborate researches. It appears, however, that this bipinnate disposition of the fibres is by no means characteristic of earthworms as a group, and is only found here and there; indeed, up to the present the only other earthworm besides *Lumbricus* where it has been recorded is in a species of *Perichæta* (*P. hasseltii* [1]); other species of this genus investigated by Perrier,[2] Horst,[3] and myself, do not present this bipinnate disposition of the longitudinal muscular coat. *Acanthodrilus capensis* must be placed in the same category with *Lumbricus* and *Perichæta hasseltii*. The disposition of the longitudinal muscular fibres agree precisely with those of the two latter species. Two other species of the genus *Acanthodrilus* differ from *A. capensis*, in that the longitudinal muscles form a continuous layer round the whole of the body, the individual fibrils being separated into groups or singly by anastomosing trabeculæ of connective tissue, which present no approximation to the symmetrical bipinnate

[1] *Loc. cit.* [2] Nouv. Arch. d. Musèum, t. vii.
[3] Notes from the Leyden Museum, vol. v., p. 185.

muscles of *Lumbricus.* It seems very curious that species of the same genus should differ so markedly in an anatomical character, which would seem *à priori* to be of considerable importance; and it is still more curious that *P. hasseltii* and *A. capensis* should agree with each other, and with a distinct genus *Lumbricus*, and differ from the other members of their own genus; such facts might be supposed to indicate that the bipinnate arrangement of the muscles represented a primitive condition which has been retained here and there but lost in the majority of earthworms. Perrier, however, states that such is not the case, and that the young of *Lumbricus* present no traces of the bipinnate arrangement of the muscles of the adult.[1]

While writing this an interesting paper by Dr E. Rohde[2] upon the muscles of Annelids has come into my hands. This anatomist has studied the structure of the body wall in a great number of different worms belonging both to the Oligochæta and the Polychæta. It appears from his observations that the genus *Lumbricus,* like *Perichæta* and *Acanthodrilus,* does not present an absolute uniformity in the structure of the longitudinal muscular coat. Certain species agree with *Lumbricus terrestris* in the regular arrangement of the fibres, while *L. olidus* differs entirely, and shows no traces of the bipinnate disposition of the fibres, except close to the line of junction with the circular muscular coat.

Acanthodrilus was instituted as a genus of earthworms by M. Perrier in his "Recherches pour servir a l'histoire des lombriciens terrestres."[3] It is to be distinguished from the other genera of the group "Postclitelliens" by the presence of *four* male generative apertures situated in pairs on the 17th and 19th segments of the body or in their immediate neighbourhood. With each of these apertures is connected a simple coiled tube—the prostate gland—and a saccular diverticulum, enclosing two or a greater number of peculiarly modified penial setæ. Three species were described by M. Perrier; two of these—*Acanthodrilus obtusus* and *A. ungu-*

[1] Arch. d. Zool. Exp., t. iii., p. 387

[2] Zool. Anzeig., No. 189 (1885), p. 135.

[3] Nouv. Arch. d. Muséum, 1872.

latus—are natives of New Caledonia; while the third—*A. verticillatus*—was obtained from the island of Madagascar.

During the Transit of Venus Expedition, the Rev. A. E. Eaton collected two small earthworms in Kerguelen, which were afterward determined by Professor Lankester[1] to belong to the same genus, and named *A. kerguelenensis.* In this species the setæ of the body have a different arrangement from that found in the previously described species. Instead of being disposed in four series of pairs, the setæ of *A. kerguelenensis* are "in eight series, each seta standing alone and widely separated from its fibres of neighbouring series." Associated with this peculiarity is an additional one, viz., the presence of segmental organs (*Cf. loc. cit.*, Fig. 4).

More recently,[2] Dr Horst has contributed an account of two other species collected in Liberia. Both of these have the normal arrangement of the setæ (four series of pairs), and segmental organs are only present in a very few segments, and then considerably modified. To these six species I am able to add a seventh, which may be called *Acanthodrilus capensis.*

Acanthodrilus capensis, n. sp.

External characters, etc.—As already said, *Acanthodrilus capensis* has very much the same general appearance as *Lumbricus terrestris*, the colour being, as in that species, a reddish violet upon the dorsal surface, passing into a yellow grey upon the ventral surface. A very noticeable characteristic of the species is its extremely active movements when handled or touched with the forceps. When interfered with in this way, the worms twist themselves violently from side to side, and will sometimes spring up into the air a short distance above the table. It is worth noting that this very same behaviour has been observed in many species of *Perichæta*, several of which have been found living in England and France, though there can be little doubt that they were originally introduced along with plants from foreign countries, or in some similar fashion. In the Jardin des

[1] Phil. Trans., extra vol., 1879, p. 264.

[2] Notes from Leyden Museum, vol. vi. (1884), No. 2, p. 103.

Plantes examples of *Perichæta* are at least as numerous as of *Lumbricus*, and the gardeners have noticed them on account of their much more active movements.[1]

The setæ are arranged in a rather peculiar fashion, intermediate between the arrangement described by Lankester in *A. kerguelenensis* and that which obtains in the other species of the genus. In the anterior region of the body, to as far back as about the 20th segment, the setæ are disposed in the following fashion. On either side of the ventral median line is a single pair of closely approximated setæ, and more laterally another pair on either side. Of this pair, however, the two setæ are much more widely separated from each other. In the hinder portion of the body, commencing after the male generative orifices, the setæ of the ventral pair get farther apart from each other, but are never so widely separated as those of the more dorsal pair.

Close to the anterior margin of segments 8 and 9 are the apertures of the four spermathecæ. Their position corresponds to that of the segmental organs, being in front of the ventral (innermost) pair of setæ.

On the 17th and 19th segments respectively are a pair of apertures, situated each upon a circular flattened area, differing somewhat by its greater opacity and whitish colour from the surrounding integument. These are the openings of the *vasa deferentia*, and like the copulatory pouches they correspond to the inner pair of setæ. Upon these two segments the ordinary setæ are replaced by the long curved penial setæ, the points of which protrude through the apertures.

Of the nine or ten specimens that I had at my disposal not a single one was fully mature; the clitellum was entirely undeveloped, and there were no indications as to its position. Several of the segments—in one specimen as many as six (segments 7-12)—are provided with a pair of genital papillæ.

Body cavity.—The mesenteries separating the segments from each other are especially well developed in the anterior

[1] Perrier, Arch. de Zool. Exp., vol. ix., p. 237, *note*. See also Baird, P. Z. S., 1869, p. 40, for similar habits of *Perichæta diffringens*.

part of the body, as in so many other earthworms. The mesenteries forming the posterior boundary of segments, 6-12 inclusive—more especially the four anterior ones—are stout and thick, and connected with each other and with the body wall by tendinous threads. In front of the 6th segment the mesenteries cease to be distinguishable as such, and their place is occupied by a mass of fibres of varying thickness and extent, which bind the alimentary canal to the parietes. A dense mass of these is attached to the posterior half of the pharynx, and serve, perhaps, as a retractor.

Well developed segmental organs are found in all the segments of the body, with the exception of the first one or two. They exist in the segments which contain the spermathecæ and the prostates. As already mentioned, *A. kerguelenensis* appears to be the only other species of the genus which has segmental organs of the ordinary type.

Circulatory System.—In segments 8-12 inclusive are a pair of lateral hearts, which connect the ventral (supra nervian) vascular trunk with a small and inconspicuous vessel which runs along the upper surface of the alimentary canal beneath the dorsal vessel. The last three pairs are the largest. It is possible that, as in *Pontodrilus,* a communication also between the lateral hearts and the dorsal vessel exists, but I could not satisfy myself thoroughly as to its presence or absence, but I am inclined to believe that it is absent. In each of these segments there is also a largish blood vessel, which arises behind the "heart," and apparently, together with it, from the supra-intestinal trunk; it supplies the mesentery and ventral wall of the body. In the posterior region of the body the dorsal vessel gives off three branches in each segment, two of which are distributed to the walls of the intestine, while the third supplies the mesentery. Anteriorly the dorsal vessel ramifies upon the surface of the gizzard.

Genital System.—The testes consist apparently of three pairs of racemose glands in segments 11, 12, and 13. This description, however, applies only to one specimen; in all the others that were dissected there was but a single pair of testes fully developed, the rest being minute and rudimentary; the developed testes were those of the anterior pair. In the

segment in front of that which contains the testes are a pair of rosette-like structure; these are the fimbriated orifices of the *vasa deferentia*. They are placed below, and a little to one side of the alimentary canal, on the posterior wall of the segment, and closely approximated to each other, being in actual contact for a short space. I failed to find the posterior pair of *vasa deferentia* funnels.

The *vasa deferentia* pass as two extremely minute slender tubes to their openings on the 17th segment, in common with the prostate gland and the sac containing the two penial setæ.

The prostate glands, as in other *Acanthodrilus*, have the form of a simple coiled glandular tube opening by a narrow muscular duct. There are four of these two in the 17th, and two in the 19th segment.

The penial setæ are developed in a sac-like diverticulum, which opens in common with the prostate of its own side and segment. The structure of the penial setæ, of which there are a single pair to each of the four generative apertures, is characteristic of the species. The seta is covered upon its lowermost one-third with numerous short pointed processes, the points of which are directed towards the extremity of the seta.

There are two pairs of spermathecæ in segments 8 and 9; each consists of a piriform sac, opening by a narrow passage on to the exterior. A small supplementary sac of the same form as the principal sac, but narrower and bent downwards, is present as a diverticulum of the spermathecæ. In the segment which contains the posterior pair of spermathecæ are a pair of largish, rounded, and somewhat flattened bodies attached generally to the septum, which divides this from the succeeding segment, but occasionally to the anterior septum also. The walls of these sacs are comparatively stout, and the contents do not present an organised appearance, but appear to be entirely granular. Interspersed among the granules are a number of gregarious cysts. I am quite unable to suggest what may be the possible function of these structures.

The position of the ovaries and their ducts in the genus *Acanthodrilus* has not yet been ascertained with certainty,

chiefly, no doubt, owing to the fact that only badly-preserved spirit specimens have been examined. In *Acanthodrilus capensis* the ovaries are in the 12th segment attached to its front wall; they are conspicuous in fully-mature animals from the contained ova, which are comparatively large and very opaque. Examined under the microscope the ovary presents the appearance of a compound tubular gland, certain of the cells becoming enlarged and forming the ova. The oviducts open into the 12th segment by a broad ciliated funnel, which has exactly the appearance of that of *Pontodrilus*, figured by Perrier. The duct perforates the mesentery, and opens on to the exterior of the body in the 13th segment just in front of the innermost seta.

Alimentary Canal.—The pharynx occupies about the four anterior segments of the body; it is somewhat pear-shaped, and terminates in an abruptly truncated posterior margin. A short œsophagus leads from this to the gizzard, and a tube of the same calibre as the œsophagus extends back to about the 16th or 17th segment, where it abruptly widens into the "intestine." The latter is unprovided with cœca or glands of any description, but is clothed with a dense covering of cells, which gives it an opaque yellow colour.

XXX. *Notes on the Anatomy of the Myriapoda.* By T. D. Gibson-Carmichael, Esq.

(Read 20th December 1883.)

I propose to submit to you a series of papers, of which this is the first, dealing with the anatomy of the Myriapoda. I intend beginning with the digestive system, and this paper is confined to that of a few of the Chilopoda. The excellent paper of Mr F. Plateau, "sur les phénomènes de la digestion chez les Myriapodes," in the forty-second volume of the *Memoirs of the Royal Academy of Belgium*, furnished us with such a clear account of both the anatomy and physiology of these organs, that it may seem unnecessary for me to write more on the subject. But as I wished to verify all that

Plateau had stated, I have dissected numerous Chilopods, and as in some ways my results are different from his, I have thought I may as well record them.

Lithobius.—Of this genus I have dissected three species, *L. grossipes*, *L. variegatus*, and *L. forficatus.* Of the first two I have only dissected a few examples, but of *L. forficatus* I have examined over a hundred specimens, and as I find that there is little difference in the digestive organs of the three species, I shall describe them as I find them in *L. forficatus.*

Lithobius appears to feed principally on diptera, at least in captivity. Plateau found this to be the case, and in the numerous experiments which I have made I have quite failed to get captive *Lithobii* to take any other food than flies, gnats, and some small neuroptera (*Sialis*, etc.) and trichoptera. It has been stated, however, that they devour worms, and that in the case of a comparatively large worm two *Lithobii* will attack it at once.

The alimentary canal is easily seen to fall into three divisions, a short œsophagus, a large stomach occupying the greater part of the interior of the body, and a short intestine. Besides these three parts we may consider also the two large glands situated in the fore part of the body, and the two malpighian tubes which open into the alimentary canal at the juncture of the stomach and intestine.

The œsophagus is short and relatively broad. When viewed in its natural position it is seen to be somewhat larger at its posterior extremity than in the anterior portion. It is generally of deep violet colour. Plateau mentions his having found it white in some *Lithobius forficatus.* I have not done so in this species, but in all the *L. grossipes* which I have dissected it was of a pale yellow, and in *L. variegatus* of a deeper purple colour than I have found it in *L. forficatus.*

It is formed of an outer muscular layer, an epithelium formed of cells of colourless protoplasm with well-developed nuclei, and a thin transparent lining, which, towards the posterior extremity, is studded with minute chitinous spines,

pointed towards the second division of the alimentary canal. In *L. grossipes* these spines seem to be much more numerous, and to extend over the anterior as well as posterior portion of the lining. The passage of the food through this portion of the alimentary canal is very rapid, none being left in it in specimens killed within a few minutes after a meal.

The second part of the alimentary canal, the stomach, is that in which the whole process of digestion goes on. It has a thick muscular coat, and an epithelium composed of a layer of large brownish cells, whose nucleus, easily shown by the agency of acetic acid, is large, and of a somewhat conical shape. Throughout this epithelium there appear to be a number of small glands, whose structure I have not yet been able to determine, which secrete a brownish fluid, by means of which the food is digested. This stomach is plentifully supplied with blood-vessels. The food seems to remain in it for a considerable time. A peculiar feature of it is, that towards its posterior end the remains of the completely digested food form a solid column which becomes entirely surrounded with a structureless membrane, from which portions break off, to pass out of the stomach from time to time as fæces. This membrane, which invests the fæces, was first pointed out by Plateau. It yet remains to be discovered whence it originates.

The intestine in *Lithobius* is short, and much narrower in diameter than the stomach. No process of digestion goes on in it, the fæces merely passing quickly through it. It is quite straight in *Lithobius*, though in other chilopods it is always bent more or less. Dufour describes a small cæcum close to the anus; but neither myself nor Plateau have found any traces of this. It has a covering of strong muscular bands, and the cells of its epithelium, which are much smaller than in that of the rest of the alimentary canal, have large nuclei clearly visible without the aid of reagents. They seem to secrete a colourless fluid, which probably aids in assisting the passage of the fæces.

The anterior glands are two large violet-coloured race-

mose glands, answering morphologically to the salivary glands of insects, though Plateau's researches show that physiologically this is not the case, for their secretion has none of the effects of saliva. Plateau was unable to discover the effect which it had, and as yet I have had no better success. The liquid secreted is certainly never acid. These glands consist of a number of nucleated cells, some colourless, others violet, in *L. forficatus* and *variegatus*; in *L. grossipes* the violet colouring is absent. They are well supplied with air, a trachea running alongside of each of their ducts, and ramifying throughout them. The ducts open, not into the œsophagus, but into the cavity of the mouth.

The two malpighian tubes are very fine and long, and originate in the anterior part of the body. Before opening into the alimentary canal they widen into a sac-like reservoir. Their secretory cells are small, but well supplied with colourless granules. They secrete pure uric acid, but in very minute quantities. In individuals which have been starved there is always a greater quantity of uric acid present in these tubes than there is in those which have lately had a meal.

The geophilides, from their small diameter, are difficult to dissect. I have succeeded, however, fairly well in *Geophilus longicornis* and in *Himantarium Gabrielis* in making out the nature of the alimentary canal. The three portions of the canal are very differently proportioned in these from what they are in *Lithobius*.

The œsophagus is a very fine tube, occupying at least one-third of the length of the alimentary canal. There are no traces of any spines or hairs in its interior lining.

The stomach much resembles that of *Lithobius*. The intestine, which is much the shortest part of the canal, differs from that of *Lithobius* in being twisted in *Geophilus longicornis* twice, in *Himantarium Gabrielis* four times.

The anterior glands, which are colourless in *H. Gabrielis*, are very elongated, though racemose, and have a long duct, which runs close to the œsophagus. In *G. longicornis* these glands take the form of tubes, thus approaching, as we shall see, the *Chilognatha*. These tubes are of much greater

diameter in the posterior, their secreting portion, and are twisted back upon themselves.

The malpighians in *G. longicornis* much resemble those of *Lithobius.* In *Himantarium Gabrielis* there is no increase in their diameter near the opening.

I hope at an early date to communicate a description of the morphology of the digestive system in other chilopods and in the *Chilognatha.*

XXXI. *On the Aeration of Marine Aquaria.* By George Brook, Esq., F.L.S., etc. [Plates XVIII., XIX.]

(Read 18th February 1885.)

In carrying on any investigations into the life history and habits of marine animals, success is greatly dependent on a close imitation of the natural conditions of existence. In some respects this is not difficult, and, besides, marine as well as other animals possess in a variable degree an adaptive faculty which enables them to accommodate themselves to new surroundings. We should always bear in mind, however, that these new surroundings are not the natural ones, and that our results obtained in a laboratory may often be influenced by conditions not to be found in a state of nature. Perhaps the most difficult natural condition to imitate, and one which affects all marine animals alike, is a proper aeration of the water. Within the limits of a laboratory tank it is not practicable to aerate the water in a natural way. The oxygenating influence of winds, waves, and tides can take only a very limited share in this work, and we have no scope for the distributing influence of currents. Naturalists have therefore had to take advantage of other methods of keeping the water pure and charged with oxygen. Two distinct methods have been tried on a large scale with varying degrees of success.[1] On the first plan the oxygen was

[1] I do not propose to deal here with those small still-water aquaria, in which advantage is taken of the mutual dependence of animal and vegetable life for a proper aeration of the water.

renewed by forcing air into the water, and by the second a continuous stream of water was kept flowing through the tanks. The first method, although quite satisfactory on a small scale, decreases in its applicability just as the size of the tank increases. The second, although perhaps more natural than any other method, is very expensive, and not applicable for an inland station. It is necessary to pump the water direct from the sea, and to return it again after having circulated through the tanks. This method also has another disadvantage. It is found by experience that water kept properly aerated improves instead of deteriorating with keeping. Forms which will not live in water newly introduced into a tank may often be kept there with ease six months afterwards. Again, that crystal appearance so characteristic of pure sea water is never to be obtained from water freshly pumped from the shore. Practically a combination of the two methods is most commonly in use. A small jet of water is forced into the tank with such a pressure as to carry air along with it.

I propose, then, to give an account of the methods and apparatus by which experience has shown that this can best be affected with due consideration of expense. When some four or five years ago I had my aquarium fitted up in Huddersfield, I was supplied with vulcanite pump, pipes, and jets, by Messrs Leete, Edwards, & Norman, similar to those supplied to the large public aquaria. I took the precaution, however, to have every jet supplied with a stopcock, so that I could vary the amount of water issuing from each jet at will. I have never regretted this precaution, and cannot too strongly recommend its general adoption in all marine laboratories. The extra expense is amply repaid by the extra convenience obtained. In discussing the various alterations in the system of aeration I have made from time to time, the subject seems naturally to fall under two heads, viz., the pumping apparatus used, and the various forms of jets experimented with. The economical and efficient result obtained is of course dependent on the combined action of the two sets of appliances, but it will be well to consider them separately.

Pumping Arrangements and Motive Power.

After careful consideration I was led to adopt water from the town mains as a motive power. It seemed advisable to make use of some power which could be cut off or started at will by some automatic arrangement, and water on this account seemed the most applicable. I decided from the outset not to supply the salt water direct from the pump to the jets, as is done in so many large aquaria, but to pump it into a store tank at a considerable elevation above the floor of the building, and use the fall thus obtained to force the water into the tanks. Further experience has shown that this is in the long run the more economical plan, and without this elevated tank I could not obtain the satisfactory results already arrived at. I began, then, with one of Ramsbottom's Water Motors, and a rotary vulcanite pump, supplied by a 1-inch pipe from the reservoir. It then became necessary to devise some automatic stop motion for the water motor, so that the whole arrangement could be stopped when the fall-tank was full, and started again when the water had run down to a certain level. A continuous circulation could then be kept up day and night without any waste, and with little or no attention.

Several modifications of the principle of the ball tap were tried with varying degrees of success, until at last one was arranged which acts perfectly, and is shown in Fig. 1. A is a wood float connected by an adjustable arm B with the lever C, which is supported on the edge of the tank by the pillar D. In use it was found that the float A, on being forced up by the water, was liable to leave the side of the tank, so that a double-jointed arm I, I′, had to be fixed on the opposite side to keep it in its place. E represents the arm which goes down to the tap, and F is a weight corresponding to that of the long rod E, so as to balance the arrangement. As the float A is forced up, of course E is lowered to a corresponding degree, and would be gradually shutting off the tap of the motor, unless steps were taken to prevent this being done until the fall-tank was full. It will be observed, however, that the arm B is slotted at its upper

end, so that the float does not begin to press on the lever until it has risen through a distance corresponding to the length of the slot. A similar slot is made where the rod E is connected with the lever of the tap, and both these slots are adjustable, so that at the time the arrangement overbalances the tank is full, and the time has arrived for the motor to be stopped. This was done gradually at first, but it was found that with a rotary pump a time arrived when the motor was working so slowly, that the pump had not power enough to lift the water the required height, and thus went on wasting power until the level of water in the fall-tank had been sufficiently lowered to start the pump more vigorously. To avoid this the present system was devised, where, instead of having an arm with a weight like F directly over the fulcrum of the lever C, a flat bar of iron, G, about 2 in. wide, is supported over C by two pillars. This bar is turned up at both ends so as to prevent the rolling weight H from falling off. The weight is made from a solid piece of iron, and turned out in the middle so as to leave a flange hanging over G on each side. For further safety a light rod, K, connects the two ends of G, so as just to allow the weight to pass under it, but sufficiently low not to allow it to leave its place on the bar. It will be seen that as soon as ever the lever C is in the slightest degree over the equilibrium, the weight H runs along the bar G, with an increasing momentum, and shuts or opens the tap instantly. This arrangement has now been in work two years, and gives every satisfaction. It is allowed to work day and night, and always stops or starts the motor at the proper time. Care should be taken to keep all the joints well greased, and the whole arrangement should be galvanised so as to prevent rust.

Next, as to the pump. As I said, I was at first supplied with a rotary vulcanite pump by Messrs Leete, Edwards, and Norman. This was kept in constant use for three years. At first it worked fairly well, and required but little attention. As time went on, however, it proved less satisfactory. I required continually the services of a mechanic, as the rotating cups were frequently out of order—as they got worn their distance apart had to be carefully regulated, or the

pump would not do its work properly. Another item which caused me no slight alarm was the great price which the pump cost to work.

In order to pump 850 gallons of sea water, it was necessary to use 1250 gallons of fresh water as the motive power, so that under the most favourable conditions 33% of power was lost, and in fact at many times a great deal more. Altogether I became dissatisfied with the arrangement, and appealed to my friend Mr J. T. Nelson of Leeds to make me a plan of a pump that would prove more efficient. The result was, that I had made a double-action lift and drive pump, placed horizontally so as not to lose its prime. The general construction of this pump will easily be understood on reference to Fig. 2. A is an accurately bored glass cylinder 12 in. long and 4 in. in diameter, obtained from Messrs Chedgey. The piston rod is of steel, coated with ebonite, and afterwards turned and polished so as to work smoothly. The piston itself is made of *lignum vitæ,* and has a round indiarubber ring in its centre so as to form perfect contact. The ends B and C are also made of *lignum vitæ,* and the valves in them are round indiarubber balls weighted inside with lead. The dotted line above the valve box at B and C indicates a groove cut out in the middle, so that, in case the valve should stick, the water can still pass through. The pipes E and E′ are in this case cast-iron lined with glass, and have an internal diameter of 2 in. The whole is bolted to a stout plank, D, and connected with the shaft of the water motor in the ordinary manner. It will be easily seen from the figure that a stroke of the piston in either direction both fills the cylinder from below, and drives the water already in the cylinder into the fall-tank. This pump has now been in work over twelve months, and has given every satisfaction. It requires very little attention, and is not liable to get out of order. With a rotary pump a certain force has to be maintained in order to lift the water the required height. Thus, if the motor should be working below its normal speed, no water is raised by the pump, and the power is wasted. The case is quite different with the pump here described; all the motions being positive, a minimum of power is lost, and

whether the motor be going fast or slow, the pump does its work in proportion.

Perhaps a comparison of the cost of working both pumps would prove interesting. I find, on reference to my diary, that from 1st September 1883 to 1st February 1884, while the old pump was working, 132,540 gallons of fresh water were used by the motor, or an average of 26,508 gallons per month, which, at 6d. per 1000 gallons, gives an average monthly cost of 13s. 3d. for water. This, indeed, is below the average cost previously, for I see from a note in the diary that the water meter was disconnected for repairs for several days in January, so that during that time the water used would not be registered. From September to December 1883 the monthly average was 28,000 gallons, which would bring up the monthly cost to 14s. From 1st March 1884 to 1st January 1885, when the new pump only was used, 145,630 gallons of water were registered by the meter, giving a monthly average of 14,500 gallons, and representing a monthly cost of 7s. 3d. Thus, to begin with, the new pump costs roughly only half as much as the old one to work. This cost has been very much further reduced by means of improved jets.

Improvements in the Construction of Jets.

It appeared to me at a very early stage in my inquiry, that the vulcanite jets, as arranged in public aquaria, do their work very inefficiently. Unless we have facilities for changing the whole body of water in a tank very frequently by means of a strong stream, it is necessary to introduce air into the water by some mechanical means, so that the oxygen it contains may be absorbed. For this purpose the smaller the bubbles of air, the more likely they are to be of service, because they require longer to rise again to the surface. Thus the water has a better chance of absorbing the oxygen they contain. Now, in the first place, the size of the orifice, and in the second, the height of the jet above the water, debars the ordinary vulcanite arrangement from bringing about these conditions. The height of the jet above the water necessitates a large orifice, or very few air bubbles will

be carried into the tank along with the stream. On the other hand, the larger the stream the larger the air bubbles carried along with it, and as these rise to the surface very quickly, they do not give time for the water to absorb its required oxygen. Thus it appeared that a very fine jet entering the water close to its surface would give a more beneficial result. In order to try this I screwed off the vulcanite nozzles and fitted an indiarubber stopper to the open end of the jet. Through this a glass tube was introduced, sufficiently long to reach the surface of the water. The end to form the jet was then drawn out to a fine point, and arranged about one-eighth of an inch above the surface of the water. By this means a very fine stream always entered the tank, and along with it an immense number of small air bubbles penetrated quite to the bottom. Many of course rose to the surface quickly, but the smaller ones remained so long in the water as to be easily traced 5 or 6 feet from the jet. In this manner less water was used in the daily circulation, and a better result obtained. In less than a week's time it was easily seen that the water presented a crystal appearance it had never shown before. The small bubbles remained so long in the water that time was given for all the oxygen to be withdrawn that could be retained. Besides there was no stirring up of the bottom, nor any signs of that turbulence which is the necessary accompaniment of a comparatively large jet. Later I adopted a form of filter and jet combined (Fig. 3), which has been retained up to quite recently. This is a simple arrangement, which proves very useful in case the water has to be pumped direct from the sea, or if the water should have become a little muddy from any cause. The drawing will sufficiently explain itself. A is a cork cut in grooves so as to allow the water to pass, and B represents the carded cotton, which must be removed when dirty. I have used various modifications of this arrangement, and tried various substances through which to filter the water. I find that carded cotton, washed before it is used in fresh water, serves every purpose. Some months ago, however, it struck me that a modification of the form of aspirator used in chemical laboratories should do even

better than anything previously tried. Besides introducing air into the tanks, this arrangement ensures that the water also is thoroughly aerated as it enters. Figs. 4 and 5 show two arrangements which have been tried. These two are most applicable for comparatively shallow tanks, while the one shown in Fig. 6 may be used in tanks of any depth. The water, in issuing from the fine pointed tube, draws in with it a current of air through the open tube, and the two form a mass of froth in the lower one. The outlet is contracted a little so as to confine this froth and make it enter the tank in the form of a stream. This arrangement gives even smaller bubbles than before. By the arrangement shown in Fig. 6 the mixed air and water are made to enter the tank at the bottom, so that the bubbles of air have to pass through the whole of the water before they can make their escape. This ensures perfect aeration, and some of the bubbles are so small as to require a lens to see them. By these improved methods the daily circulation has been reduced to 620 to 630 gallons, and the motor only uses 340 gallons to pump this quantity. Thus the cost of circulation has been reduced from 14s. a month to 5s. I should mention that the 14s. a month does not represent the cost when the vulcanite jets were in use; these were soon found to be so expensive, that they quickly gave way to the plain glass tube arrangement, and I kept no account of the daily circulation at that time.

Altogether, the water in my aquarium, which has never been changed since the commencement, was never in such good condition as it is at present, and never contained as great a quantity of microscopic life.

Although this system is so generally applicable and so satisfactory, it must not be supposed that I recommend its universal application. Probably no single system of aeration is equally advantageous for all marine organisms. Although pure and well aerated water is a necessity for nearly all, it is also necessary to be acquainted with the natural habitat of any particular form before one is able to arrange a system of circulation suited to its requirements. For instance, *Anemonia sulcata* (*Antheus cereus*), one of the commonest anemones in

the English channel, is found to flourish best between high and low water marks. It fixes itself to ledges of rock, or in shallow rock pools, in such a manner, that as the tide ebbs the anemone is barely covered with water. In places where any depth of water is left over this species at ebb tide, it will always be noticed that a strong current exists, as for instance at Gibraltar, where, in a narrow channel through which a constant strong current flows, the bottom is perfectly carpeted with this species. It appears then that for such forms as *A. sulcata* well aerated water is not sufficient—there must be in addition a strong and constant current. Many years' experience has shown that this is the case. In the large public aquaria it has been found impossible to keep this beautiful anemone more than six months in the ordinary tanks, and in order to keep it longer and in all its brilliancy I have found it necessary to imitate artificially the carpet garden near Gibraltar.

XXXII. *Investigations on the Movements and Food of the Herring, with additions to the Marine Fauna of the Shetland Islands.* By FRED. G. PEARCEY, Esq., of the "Challenger" Expedition. [Plate XX.]

(Read 21st January 1885.)

In June last, when the Scottish Sea Fishing and Curing Company (Limited) was formed, a berth on board the "Energy," one of their three vessels, was kindly placed at the disposal of Mr John Murray, V.P.R.S.E., of the "Challenger" Expedition Commission, for the purpose of allowing a naturalist to accompany her on a trial cruise to the Shetland fishing grounds. Advantage was at once taken of this offer, which it was seen would afford great opportunities for the further study of the now great problem of the development, migration, and food of the herring and other food fishes, together with biological, physical, and meteorological work, the result being that I was invited to accompany her for a few weeks, an offer which I gladly accepted.

Accordingly on the 21st June I embarked on board the "Energy," taking with me the necessary collecting apparatus, consisting of dredge and all the dredging appliances, sounding rod and line, towing nets, microscope, with reagents, surface and deep-sea thermometers, also hatching boxes for developing the herring ova if an opportunity should show itself.

The Company's vessels are fitted out on the Dutch plan, for curing herring and other fish at sea, with the addition of steam-power for working the nets.

The "Energy" is a smack-rigged vessel, carrying two masts, main and mizzen, the mainmast being fitted so as to be lowered at sea to ease the weight of the vessel when riding at the nets or lines. She was also furnished with a patent steam capstan, which greatly facilitated the hawling in of the herring nets or long lines. The size of the vessel will be understood from the following dimensions:—Length of keel, 74 feet; breadth of beam, 20 feet; depth of hold, 10 feet; registered tonnage 76, and an average carrying capacity of about 120 tons. Appliances for curing were fitted on board, consisting of large troughs 2 feet deep, on either side of the deck, fore and aft, with tubs and trays for gutting, etc., also a full complement of nets, buoys, hand and long lines, and the requisite quantity of salt and barrels.

In addition to the provision for curing on board, there were also arrangements for "rousing" or salting in bulk, when the takes of herring should be so large as to prevent the curing being overtaken within twenty-four hours, the time allowed by the Fishery Board Regulations for curing herring, cod, ling, and other white fish.

The captain, John J. Tulloch, a Shetlander, well acquainted with the North Sea, and especially the Shetland Islands, with a crew of five men, one cooper, and four apprentices, eleven in all, constituted the ship's company.

The "Energy," after clearing May Island and the Firth of Forth, took a north-easterly course along the Kincardine and Aberdeen coasts.

By 12 noon on the 22d we were becalmed 6 miles off the mouth of the river Tay, so that I was able to work the sur-

face towing nets, which gave great quantities of the beautiful little Ctenophore, *Beroe cucumis*, Anhelid larvæ, Zoceæ, Amphipods, free swimming larvæ of *Balanus*, *Appendicularia*, many large Medusæ (*Aurelia aurita*), and Diatoms, such as *Coscinodiscus*, etc. The temperature of the surface was 50°·5. Later in the afternoon a light breeze sprang up, and the sea surface water was noticed to change, as we sailed slowly onward, from a beautiful sky blue to a dirty green colour. The towing net showed the latter colour to be due to a great quantity of argillaceous matter in the water, probably flowing from the river Tay. Very little animal life was found.

The afternoon of the 23d was spent in trying to beat round Peterhead, but this was not accomplished, owing to the wind dropping to a dead calm. Taking advantage of this, I was enabled to work the towing nets, and obtained the following animals:—*Thysanopoda*, Amphipods, Zoœæ, Copepods, *Balanus* larvæ, *Appendicularia*, *Peridinium*, *Beroe*, and a few Diatoms.

At 9 P.M. a fresh breeze sprang up from the south-west, and this being a favourable wind for us, we were able to make good progress passing Peterhead. At 10 P.M., with the barometer falling steadily, a great deal of phosphorescence was noticed on the surface of the water, which, on examination, was found to be caused greatly by the *Nyctiphanes* (*Thysanopoda*) *norvegica*, M. Sars, and Zoœæ.

At 9 A.M. on the 24th we were 30 miles north-east by north off Kinnairds Head, when another complete change in the colour of the sea was observed from a light blue to a milky or slate green. Several buckets of water were drawn, and some taken with a large glass jar, all of which was exceptionally clear. The tow-nets were worked for half-an-hour in this locality, and with the exception of one or two Copepods, no pelagic animals were present. It took the "Energy"—going fully 5 miles an hour—about three-quarters of an hour to pass through this belt of peculiar coloured water before emerging again into the ordinary blue sea. During this time the temperature of the surface was taken at intervals of 15 minutes, and read as follows:—51°·5, 51°·8, and 51°·9. At 4 P.M. the surface temperature had fallen to 49°, and this seemed to me a very remarkable coincidence.

The depth as shown on the chart, where the belt of coloured water was observed, is 58 fathoms, with a bottom of sand and shells.[1] It is possible that the colour of the water may, to a small degree, be due to the reflection from the white sand at the bottom; it certainly was not due to any organisms or suspended matter.

At 5 P.M. a complete change took place in the weather. A heavy drifting mist set in, while the wind had increased to half a gale, causing the ship to labour heavily under close reefed sails. Fair Island (misnamed so) was sighted, and passed at 8.30 P.M. By this time the wind had increased to fully a gale in force, and at 9 P.M. the barometer had fallen to 49°·04. It was with the greatest difficulty we were able to move about the decks. This continued till 1 A.M. on the 25th, when Sumburgh Head was sighted and passed, and soon afterwards we entered the quieter waters of Mousa Sound. At 2.30 A.M. we cast anchor off Lerwick after a very unpleasant 12 hours' sailing. Notwithstanding the bad weather many biological and meteorological observations continued to be taken.

Two days were spent at Lerwick discharging the superfluous material brought from Leith, refitting the "Energy" with small sails, and putting her in proper order for the fishing. During this stay I occupied myself in investigating the pelagic life of Lerwick harbour and Bressa Sound, which I found contained an enormous quantity of algæ, chiefly *Rhizosolenia Shrubsolei* (Cleve), giving the water a dark brown colour, and amongst the Diatoms were a few Gasteropod and Lamellibranch, Annelid and other larval forms. The temperature of the surface water was 49°·6, and the bottom 49°.

At 10 A.M. on the 27th, all being ready, the "Energy," with a rising barometer, wound her way through the narrow north entrance to Lerwick harbour, passing Rova Head and Dales Voe on our left. We had a magnificent view of Noss Head, with its high perpendicular cliffs, round which myriads of sea birds were flying. At 9 P.M. we were 37 miles west ¼ south of Noss Head, and a sounding was taken in 70 fathoms,

[1] See accompanying track chart.

which showed a bottom of shell-sand. The surface temperature was 50°·5, and the bottom 49°·2.

Here the herring nets were set for the first time, and before going further, it may be interesting to describe the method in which they were wrought.

In the first place the ship is brought head to wind, and all the sails are taken in except the jib and mizzen sail or spanker. The helm is lashed close over to one side, so as to keep the ship steady and in position, in this manner the ship is allowed to drift slowly with the wind while the nets are paid out over the quarter. For this purpose the whole of the crew is required; two hands below in the hold to ease and clear the nets as they are passed on deck, one in the hawser or spring-back locker, four to attend the nets as they are passed over the weather side, one to attach the buoys to the nets and spring-back, two to attend the spring-back, and one to keep the whole clear as they enter the water. Then the end of the spring-back, which is intended to keep the nets in position, is passed up out of the locker, and a large sheepskin buoy is attached to the end, which is passed out over the bow for a few yards; the nets are next let out over the weather quarter and brought to the bow of the ship, with a cork buoy attached at intervals of three yards, and sheepskin buoys are attached to the spring-back and nets alternately. In this way they are paid out as fast as the ship is drifting to leeward.

In hauling the nets on board again the spring-back is attached to the steam-winch, and hauled in over the bow. By so doing all the strain is taken off the nets, which, as the buoys are detached at the bow and passed along the side of the ship, are taken on board in the same manner as they were paid out over the quarter. The herring are then shaken out on deck or into the troughs, and the nets, spring-back, buoys, etc., are stowed away ready for the next cast. After all the nets are taken in the crew at once set to work gutting, curing, and packing in casks ready for the market.

During the operation of laying out the herring nets I worked the tow-nets from the surface down to 5 fathoms—one of these tow-nets was made of a fine muslin and the other of a coarser material. When the nets were hauled on

board, after dragging slowly for an hour, they contained a great quantity of the same Alga which was obtained in Lerwick Harbour and Bressa Sound, and with the exception of a few Copepods no other animal life was noticed amongst it.

From the 25th of June till the 12th July, the "Energy" fished with herring nets, lines, dredge, swabs, and tow-nets, down the east coast, round the extreme north end of the islands, and up again off the west side of Foula and Fair islands, from 10 to 80 miles off land, which is shown by reference to the accompanying chart. Our greatest catch of herring was taken midway between Fair and Foula Islands, with a surface temperature of 52°·5, and the bottom water at 50° Fahr.

My daily routine of work was as follows, viz., at 4.30 A.M. the herring nets were hauled on board, and the herring gutted, their viscera thrown into a tub set aside for that purpose, and afterwards carefully examined by me, notes taken, and contents preserved for future examination; at 9 A.M., 12 noon, and 9 P.M. meteorological observations,[1] a sounding, temperature of surface and bottom water was taken and noted. The tow-nets were kept working continually night and day at the surface and intermediate depths, notes taken, and their contents preserved. When weather permitted the dredge, or several swabs attached to a rod of iron and weighted with sounding leads, was worked, and the animals from the bottom obtained; specimens of the deposits of each sounding were also preserved. In this manner the nature of the surface and bottom at each station was determined. At 9 P.M. the herring nets were again laid out for the night, after which the hand lines were worked with good results often to well nigh midnight, the fish taken in this manner consisting of cod, ling, saith, tusk, haddock, and innumerable piked dogfish (*Acanthias vulgaris*), also a shark (*Scymnus borealis*), all of which were carefully examined, and the contents of their stomachs noted and preserved. During the cruise no absolutely full herring were caught, although I

[1] The meteorological observations will be found in the Proceedings of the Meteorological Society's Journal for 1885.

watched very closely for them, hence I was unable to make any experiments with fertilisation.

This work continued almost without intermission till the 12th of July, when, owing to the inclemency of the weather, we put into Scalloway, where I finally left the "Energy."

Remarks on the Food and Movements of Herring.

A good deal of late has been written upon this subject, and much valuable information has been collected, but no definite conclusions seem to have been arrived at. During the cruise of the "Energy" round the Shetland Islands the herring nets were worked, with one or two exceptions, every night. The exact position where the nets were drawn will be seen by reference to the accompanying chart. The position of the ship, the surface and bottom temperature, were taken, and when an opportunity occurred the nature of the bottom was determined; collections of surface animals were also continuously made. All the herring caught were immediately gutted, and their viscera thrown into a tub set aside for that purpose, the stomachs being afterwards more carefully examined. In this manner I was able to examine the stomachs of most of those caught during the cruise, and the most remarkable result of my observations has been the record of their emptiness—fully 90 per cent. being devoid of food material—so that it was only on rare occasions I found one containing what may be termed a full meal. When this was the case it consisted principally of young fish such as *Ammodytes*, *Motella*, and *Gadus pollachius*, and in some cases these were mixed with a few Copepods, the zoœæ stage of Brachyura, *Evadne*, larvæ of Mollusca, Radiolaria, etc. Three tubes, each containing some of the preserved contents of the herring stomachs, have been carefully examined, and the results are as follows:—

Tube No. 1.

One specimen of a young fish presented the following characters:—Length, 13 mm.; colour, yellowish; shape, elongated; dorsal fin not prominent, but close to tail; single anal fin not prominent, close to tail, and opposite the dorsal fin;

pectoral fins, immediately behind the head; snout, elongated; upper surface of snout, concave; no pelvic fins visible; pigment spots on the dorsal surface of the head and along the body—above and below—on either side, hence possibly the specimen was *Ammodytes.* All the other specimens, 22 in number, were probably the young of *Brosmus brosme* (White). They were somewhat like *Ramiœpe raninus* (Collett), being provided with soft fins, having the pelvic and jugular in their normal positions and very long, consisting of three or four curved separate rays; the pectoral fin was small and rounded; the dorsal fin continuous from a joint behind the head to the tail; the ventral fin continuous from tail to anus; the head was globular, mouth small, and the lower jaw did not project. There was also a slight prominence at the tail of a rounded form. Their length varied from 5 to 7 mm.

Tube No. 2.

This contained one clotted piece, with a number of cases of *Tintinus denticulatus*, Copepods, and Molluscan larva; four specimens of fishes, 5 to 6 mm. long, provided with fins continuous round the tail; thoracic pelvic fins, and the anus situated far from the tail, the head being globular. The specimens, however, were not old enough to identify. Mr J. T. Cunningham informs me, they resemble somewhat those which were hatched at the Marine Station, Granton, from adhesive eggs. This tube also contained a single specimen of *Ammodytes.*

Tube No. 3.

Here were found 20 to 30 specimens of young fishes, some much digested, others less so. In the latter case I was able to find specimens having three dorsal fins with soft rays and two ventral fins, hence probably they belonged to the genus *Gadus.*

The tow-nets were kept working continually night and day throughout the cruise, and I was therefore able to compare the pelagic animals obtained with the contents of the herring stomachs at the exact spot where they were caught. Where our finest catch of herring was taken, I spent a whole day

in examining the contents of their stomachs; over a thousand of the largest were dissected, and it was found that not more than three or four in a hundred contained food. It is somewhat remarkable that this food consisted almost entirely of young fish. One of the most perfect specimens was kindly identified for me by Dr Francis Day (*Gadus pollachius*). It is worthy of note that no young fish of the above species were taken in the surface gatherings, while others of the genus *Ammodytes* and *Motella* were in some localities quite common. After examining my notes on previous investigations upon the same subject, I am convinced that the herring feed upon most, if not all, of the minute animals which live in or near the surface waters of the sea; and wherever these are abundant, there the herring will be found in the largest quantities. There can be no doubt that the herring, like most other fish, is a voracious feeder: nothing in the way of food seeming to come amiss. The abundance of its food, as well as suitable localities for depositing ova, are, in my opinion, the principal causes of their apparently haphazard movements. The temperature of the water does not seem to me to have much, if any, effect on the movements of the herring; but this may not hold good as far as the propagation of their young on the spawning grounds is concerned. It is, however, impossible to draw definite conclusions on such extremely short investigations. It will be for future investigators to show whether the variation of temperature has anything to do with their movements. The average temperature of the sea surface all round the Shetland Islands from the 24th June to the 12th July was 52° Fahr., and the bottom temperature 50°. Where our greatest catch of herring was taken, the surface temperature was 52°·5 when the nets were laid out, and 51°·9 when hauled in.

This change of temperature took place during six hours while the "Energy" was drifting slowly with the nets. On the east side of the Shetland Islands, as far as could be made out by the position of the nets and the way the herring were caught in them, they were swimming in a south-*east* direction; while on the west side of the islands they were swimming in a south-*west* direction.

Professor Cossar Ewart, in a paper read before the Royal Physical Society[1] on the subject of the deserted spawning-grounds of the herring, says: "One of the best known banks visited in the autumn is the Guillan Bank, while the bank at Ballantrae is the most familiar resort during the spring; but in addition to these there are many others well known to our fishermen. All these spawning-grounds are liable to be deserted for longer or shorter periods, *e.g.*, Guillan Bank has practically been deserted during the last fifteen years; the bank off Dunbar has been deserted for a still longer period; the Ballantrae bank was all but deserted for several years; while the herring shoals left the Bohuslän grounds in 1808, and did not make their appearance again in any numbers until 1877."

The desertion of the herring from the spawning-grounds mentioned above, I am of opinion, may be partly, if not wholly, attributed to the following causes. In the first place, the fishermen have been complaining for several years of the great numbers of sharks and dog-fishes which frequent, or have remained, in certain localities known to be, or to have been, spawning-grounds of the herring, and where immense catches of herring were formerly taken; but since the arrival of the sharks, it is sure ruin to lay their nets, as they are either lost altogether or torn to pieces by them. An illustration of this presented itself during the cruise of the "Energy" off the west coast of the Shetland Islands, once a famous spawning-ground of the herring. Our nets, 70 in number, were laid out after sunset in the usual way, and during the night the piked dog-fish (*Acanthias vulgaris*) were so numerous swimming near the ship, that any number might have been caught by the trident or harpoon; indeed, the men could scarcely put over their hand-lines without hooking one, and the sea for a considerable distance round us seemed to be alive with them. The nets, in consequence, had to be hauled on board much sooner than usual, the catch at this time amounting to only three barrels, 80 per cent. of which were so badly bitten, that they were of no use, and in a great many cases only the heads of the herring remained

[1] Proc. Roy. Phys. Soc., vol. viii., part 1.

in the nets, which were also badly torn. Hence, it would appear that the sharks, when once properly located, remain in or near the same ground, where they have been, and probably are still, abundantly supplied with food; and the once favourite spawning-ground of the herring is naturally shunned by them for a more quiet and suitable locality. Secondly, for the last three years the fishermen at the Shetland fishing grounds have been sorely tried by loss of time and expense incurred in replacing their nets, owing to the enormous quantity of vegetable matter, which they regard as dirt in the water. This matter is almost exclusively diatomaceous, consisting of the living frustules of *Rhizosolenia Shrubsolei* and *Thallasiosira Nordenskiöldii*, which we have already referred to, and which, in addition to destroying the fishermen's nets, emit an exceedingly disagreeable odour.

This was also my experience while on board the "Energy," as we often passed through huge dense banks of it.[1] Between these were spaces of clear water, so that the nets were frequently stretched across the *Rhizosolenia* banks and clear spaces together; in every case where the nets were lying among *Rhizosolenia* not a single herring was caught, while outside of the diatomaceous zones they were found in abundance. Many experiments were made to test the exclusive power of the Diatoms, all giving the same results.

Not being able to account for so much vegetable matter, and little or no animal life in the surface water, I determined to make some experiments as to how deep the algæ were to be found, and whether the pelagic life was more abundant underneath the algoid material. Accordingly, three nets were worked for an hour simultaneously, one on the surface, one at 10 fathoms, and the other at 20 fathoms; all three were taken on board with great quantities of algæ. The one at 10 fathoms, however, contained the most, showing that it was in greater quantities at 10 fathoms than either at the surface or at 20 fathoms.

I have never before observed algæ to have such a decided effect on the water. In two localities, during the "Challenger" Expedition, viz., Arafura Sea and the Antarctic Sea, algæ

[1] The localities are indicated by brown patches on the chart.

were taken from the surface in great abundance, so much so in the Antarctic, that their dead frustules made up the deposit at the bottom, forming a diatomaceous ooze; but at neither of these places had it such an effect in colouring the water, nor was there any offensive odour as when taken in mass in the north by the tow-nets. The herring nets were often thickly coated with this algæ, but the phosphatic odour given off was so offensive at times, that the men could scarcely remain at work, and were only able to do so by allowing the nets to run through tubs of fresh water as they were hauled on board. Little heaps of the algæ were formed on the deck, as it dropped from the nets. These heaps were to the touch slimy masses, similar in colour to molasses, and the nets from which they fell had to be carefully washed before being again used.

There can be no doubt, then, that this vegetable matter exercises a very great influence over the herring and the pelagic animals upon which they feed, as very little animal life was found amongst it. In support of my observations, I have received a letter on the subject from Mr W. H. Shrubsole of Sheerness, with whom I had put myself in communication. He says:—

"I have often met with *Rhizosolenia* here in small quantities, and in 1880 or '81 I found that the water of the Thames estuary was crowded with it; each time I dropped my tow-net over, in a few minutes it was lined with this diatom so thickly as to present a dark velvety appearance, and a very peculiar and powerful odour was emitted. You may be interested to know that every year, about May and June, another organism (an alga) abounds in these waters, which fishermen think to be fish spawn; they say it rots their nets and ropes. It certainly causes such things to feel very slimy."

There has not been time to carefully investigate and identify all the various organisms taken in the tow-net gatherings. I have therefore merely given the list of the different groups from a few stations, and the localities from which they were obtained, showing where the herring were

taken in abundance and where few or no herring were caught.

1. — Herring Plentiful.

NOSS HEAD, W. ½ N. 30 miles, . . } Surface Temperature,
SKERRY LIGHT, N.W. ¼ N. 19½ miles, } 50°·3.

Annelid larvæ, . . . many.
Zoœæ, ... many.
Copepods, ... common.
Globigerina bulloides, many, covered with their beautifully delicate spines.
Radiolaria, ... few.
Appendicularia, . . . common.
Peridinium, ... few.

2. — Herring Plentiful.

SKERRY LIGHT, W. ½ N. 27½ miles, . } Surface Temperature,
LAMBA NESS, N.W. by N. 31 miles, . } 50°·4.

Young Fish (*Motella*), . many.
Young Fish (*Ammodytes*), several.
Molluscan larvæ, . . . many.
Zoœæ, ... many.
Copepods, ... common.
Echinoid larvæ, . . . few.
Globigerina bulloides, . few.
Globigerina inflata, . . several.
Radiolaria, ... few.
Tintinus denticulatus, common, the ciliary movement of which was seen distinctly, but the endochrome disappeared when placed in spirit.
Appendicularia, . . . common.

The localities are indicated by the cross-shaded patches on the accompanying chart.

3. — No Herring.

Diatomaceous Zone, chiefly *Rhizosolenia Shrubsolei*.

4. — Few Herring.

VE SKERRIES, E. by N. 12 miles, with a drift over the same bearings of 5 miles, ... } Surface Temperature,
FOULA ISLAND, E. side, S. ½ W. 9 miles, } 52°·2.

Copepods, ... very few.
Zoœæ, ... one.
Radiolaria, ... several.
Medusæ, ... several.
Rhizosolenia, ... common.

5. Herring Abundant.

SUMBURGH HEAD, E. by N 12 miles, . NORTH FRONT OF FAIR ISLAND, 13 miles, ... — Surface Temperature, 52°·5.

Young Fish (*Ammodytes*), .	many.
Young Fish (*Motella*), . .	few.
Molluscan larva, . . .	many.
Globigerina bulloides, with spines,	many.
Radiolaria (compound), . .	few.
Beroe, ...	few.
Appendicularia,	many.
Peridinium tripos, . .	common.
Peridinium sp., . .	many.
Tintinnus denticulatus, .	few.

6. SCALLOWAY HARBOUR, 11th July.

Gastropod larva, . . .	very common.
Annelid larva, . . .	many.
Zoeæ, ...	many.
Copepods, . .	many.
Echinoid larva, . .	few.
Medusoid gonophores, . .	many.
Diatoms, ...	few, such as *Coscinodiscus*

It is worthy of note that no *Rhizosolenia* was found here.

LIST OF OBSERVING STATIONS.

Station 1. FLOGGER LIGHT, W. ½ N. 25 miles. Depth, 125 fathoms.
Surface temperature, 53°·5; bottom temperature, 49°·3.

Station 2. OSSA SKERRY, S.W. by S. ½ S. 7 miles.
UNA BASS, E.S.E. 5 miles. Depth, 56 fathoms.
Surface temperature, 54°; bottom temperature, 48°·6.

Station 3. VE SKERRY, E. by N. 12 miles.
FOULA ISLAND, S. ½ W. 7 miles. Depth, 73 fathoms.
Surface temperature, 52°·3; bottom temperature, 51°·8.

Station 4. SUMBURGH HEAD, E. ¾ S. 8 miles.
FAIR ISLAND, S.W. ¼ S. 15 miles. Depth, 58 fathoms.
Surface temperature, 52°·5; bottom temperature, 48°.

Station 5. FAIR ISLAND, S. ¼ E. 18 miles.
SUMBURGH HEAD, E. by S. ½ S. 18 miles. Depth, 70 fathoms.

Station 6. BIGHT OF HAMES, Bressay. Depth, 6 fathoms.

Station 7. Off SUMBURGH HEAD, 11 miles. Depth, 75 fathoms.

Station 7A. SUMBURGH HEAD, S.E. by S. 14 miles. Depth, 76 fathoms.

Station 8. Lat. 58° 45′ 0″ N., long. 0° 55′ 0″ E.; depth, 85 fathoms.

LIST OF ANIMALS collected during the cruise of the Fishing Smack "Energy," arranged in their order of classification.

CŒLENTERATA.

HYDROIDA.

Eudendrium ramosum (Linn.).	Stations	1 and 8.
Tubularia indivisa, Linn.	„	2, 4, and 8.
„ *larynx*, Ell. and Sol.	„	4.
„ *coronata* (Abildg.).	„	5.
Clytia johnstoni (Alder).	„	4.
Companularia raridentata, Alder?	„	4, 5.
„ *verticillata* (Linn.).	„	4, 5.
Gonothyrœa hyalina, Hincks, on *Tubularia*.	„	5.
Obelia dichotoma (Linn.).	„	2, 6.
Lafoea dumosa (Flem.), on *Sert. abietina* and *Hydrallmania*.	„	5, 7, 7A.
Coppinia arcta, Dalyell, on *Sert. abietina*.	„	4.
Halecium halecinum (Linn.).	„	5, 7, 7A.
Sertularella polyzonias (Linn.).	„	4.
„ *gayi*, Lam.	„	2, 4.
Diphasia pinnaster (Ell. and Sol.).	„	2.
Sertularia filicula (Ell. and Sol.).	„	4.

Sertularia abietina, Linn.	Stations 4, 5.
„ *cupressina*, Linn.	„ 4, 5.
Hydrallmania falcata (Linn.).	„ 5, 7A, 8.
Thuiaria thuja (Linn.).	„ 4.
Antennularia ramosa (Lam.).	„ 3.
Plumularia pinnata (Linn.).	„ 3, 5.

ECHINODERMATA.

Ophiuroidea.

Ophiopholis aculeata (O. F. Müll.).	Stations 2, 3, 7, 7A.
Ophiocoma nigra (O. F. Müll.).	„ 6.
Ophiactis Ballii (Thomps.).	„ 2.
Ophiothrix pentaphyllum (Pennant)	„ 2, 3, 6, 7A.
Ophiactis abyssicola (Sars).	„ 2.

Asteroidea.

Asterias rubens, Linn.	Stations 1, 2, 6.
„ *glacialis*, Linn., young.	„ 8.
Luidia Sarsii (Dub. and Koren).	„ 8.
Astropecten irregularis (Pennant).	„ 3, 7, 7A, 8.
Solaster papposus (Linn.).	„ 1.
Cribrella sanguinolenta (Müll.).	„ 2, 7, 7A.
Stichaster roseus (O. F. Müll.).	„ 2, 7.

Echinoidea.

Echinus miliaris, Leske.	Stations 2.
„ *norvegicus*, Düb. and Koren, abundant.	„ 3, 5, 6, 7, 8.
Strongylocentrotus dröbachiensis (O. F. Müll.).	„ 5, 6, 7.
Cidaris papillata, Leske, a single fine specimen, taken with hook and line in 70 fathoms off Fair Island by a fisherman.	
Echinocyamus pusillus (O. F. Müll.).	„ 2.
Spatangus purpureus (Muller).	„ 2, 3, 4, 5, 7, 7A.
Echinocardium cordatum (Penn.).	„ 7.
Brissopsis lyrifera (Forbes).	„ 7, 7A.

HOLOTHUROIDEA.

Cucumaria frondosa (Gunner), a single specimen from Lerwick Harbour, 7 fathoms.

POLYZOA.

Bugula avicularia (Pallas), several fine specimens.	Stations	1, 2, 5.
„ *murrayana* (Bean).	„	7A.
„ *purpurotincta*, Norman.	„	5.
Cellaria fistulosa (Linn.).	„	2, 4.
Microporella ciliata (Pall.).	„	7.
Schizoporella linearis (Hassall).	„	7.
Porella compressa (Sowerby), abundant.	„	2, 7, 7A, 8.
Retepora beaniana, King, abundant, and fine specimens.	„	1, 2, 7, 7A.
Cellepora pumicosa, Linn.	„	2, 4.
„ *ramulosa*, Linn.	„	1, 2, 7, 7A, 8.
„ *dichotoma*, Hincks, chiefly on *Halecium* and other Hydroids.	„	1, 7A, 8.
Hornera lichenoides (Linn.).	„	2, 7A.
Idmonea serpens (Linn.).	„	4, 7A, 8.
Diastopora patina, Lam.	„	2, 7, 7A.
„ *obelia*, Flem.	„	7.
Stomatopora sp.	„	7.

CRUSTACEA.

CIRRIPEDIA.

Scalpellum vulgaris, Leach. Station 4.

COPEPODA.

Caligus rapax, M. Edws., with *Udonella caligorum* attached. From a cod.

AMPHIPODA.

Gammaropsis erythrophthalmus, Lillje-borg. Stations 2, 7, 8.

Cerapus difformis, M. Edws., ♂ and ♀.	Stations	7.
Podocerus minutus, G. O. Sars, ♂ ♀. This species has not been previously recorded as British. Shetland specimens, however, exist in Dr Norman's collection (under a MS. name) found by him in 1868.	„	8.
Proto ventricosa (Müll.), *P. pedata*, Leach, *P. goodsiri*, Bate.	„	1.
Amphithopsis latipes, Sars.	„	8.
Calliopius ossiani, var. *fingalli*, B. and W.	„	8.
Pherusa fucicola, Leach.	„	2, 8.
„ *bicuspis* (Kröyer).	„	8.
Stenothöe pollexiana (Bate).	„	8.
„ *monoculoides* (Mont.), ♀.	„	8.
Microprotopus maculatus, Norman.	„	8.
Microdeutcropus anomalus (Rathke), ♀.	„	8.

Isopoda.

Cirolana spinipes, Bate and Westw.	Station	2.
Astacilla longicornis, Sow.	„	8.
Janira maculosa, Leach.	„	7.

Decapoda.

Hippolyte pusiola, Kröyer.	Stations	6.
Nephrops norvegicus, Linn.	„	1.
Galathea intermedia, Lilljeborg.	„	6.
„ *dispersa*, Bate.	„	7.
Eupagurus pubescens (Kröyer), in *Purpura lapillus*.	„	6.
Porcellana longicornis, Penn., white var.	„	6.
Hyas coarctatus, Leach.	„	2, 4, 5, 6, 8.
Portunus tuberculatus, Roux, from a cod's stomach.	„	5.

TUNICATA.

Ascidia virginea, O. F. Müll.	Station 6.

PORIFERA.

Isodictya infundibuliformis (Linn.).	Stations 7.
Phakellia ventilabrum (Linn.)? a single specimen.	„ 1.
Tethea cranium (Müll.), several specimens.	„ 2, 7, 7A.
Dictyocylindrus hispidus (Mont.).	„ 2.

VERMES.

Aphrodite aculeata, Linn.	Stations 8.
Lepidonotus squamatus, Linn.	„ 5.
Filigrana implexa, Berk.	„ 7, 7A.
Pectinaria sp. (tube).	„ 8.
Lanice conchilega, Pallas.	„ 2.
Serpula vermicularis, Linn.	„ 2, 7, 7A.
Spirorbis lucidus, Mont., on Hydroids.	„ 4, 6, 7.
Nothria conchylega, Sars, several specimens.	„ 1, 8.

PYCNOGONIDA.

Nymphon brevirostre, Hodge.	Stations 2.
Pycnogonum littorale, Strom.	„ 7, 7A.

MOLLUSCA.

Brachiopoda.

Terebratula caput-serpentis, Linn., one living specimen and small valves.	Station 5.
Crania anomala, Müll., several specimens on a stone.	„ 7.

Lamellibranchiata.

Anomia ephippium, Linn., var. *squamula*.	Stations 2, 7, 7A, 8.

Pecten opercularis, Linn., dead valves.	Stations 2.
„ *tigrinus*, Mull., dead valves.	„ 5.
„ *striatus*, Müll., two living specimens.	„ 5, 7.
„ *similis*, Laskey, a single valve.	„ 2.
„ *maximus*, Linn., a living specimen.	„ 3.
Lima subauriculata, Mont., single valves.	„ 5.
Mytilus phaseolinus, Phil., single valves.	„ 5, 7.
Crenella decussata, Mont., single valves.	„ 7.
Montacuta substriata (Mont.), living on *Spatangus purpureus*.	„ 5, 7, 7A.
Lucina borealis, Linn., a single valve.	„ 7.
Astarte sulcata (Da Costa), fragments.	„ 7.
Scrobicularia prismatica, Mont., a single valve.	„ 7.
Mya truncata, Linn., a single valve.	„ 7.
Saxicava rugosa, Linn., var. *arctica*, living.	„ 2.

Solenoconchia.

Dentalium entalis, Linn., dead shells.	Stations 7, 7A.

Gastropoda.

Chiton ruber, Lowe.	Stations 6.
Natica montagui, Forbes, dead.	„ 4.
Purpura lapillus, Linn., dead.	„ 6.
Trophon barvicensis, Johnst., a single dead specimen.	„ 4.
Fusus gracilis, Da Costa, one living specimen.	„ 5.
Nassa incrassata, Mont.	„ 2, 7A.
„ „ var. *minor*.	„ 2, 6.
Defrancia linearis, Mont., dead.	

CEPHALOPODA.

From Herring Nets.	*Todarodes* (*Ommatostrephes*) *sagittatus* (Delle Chiajé).	Station 2.
From Stomach of a Cod.	*Eledone cirrosa* (Lamk.).	„ 2.

EXAMINATION OF SEA BOTTOM.

Specimens of the deposits from thirteen localities have been examined and the Foraminifera determined.

Particulars as to locality, physical conditions, etc., are given in the description of each sounding, No. 1 to 11 and stations 1 to 5 corresponding to the headings of the columns in the distribution table.

Station 1. FLOGGER LIGHT, W. ½ N. 25 miles. Depth, 125 fathoms.

Surface temperature, 53°·5; bottom temperature, 49°·3.

A bluish sandy ooze, with fragments of Mollusca and Echinoderms; Foraminifera abundant, both pelagic and bottom living species, notably *Globigerina*, the Arctic variety, *G. pachyderma*, *G. bulloides*, also *Discorbina* and *Truncatulina*.

Station 5. FAIR ISLAND, S. ¼ E. 18 miles.
SUMBURGH HEAD, E. by S. ½ S. 18 miles. Depth, 70 fathoms.

A brown shell sand made up chiefly of fragments of Gasteropod and Lamellibranch shells, *Serpulæ* tubes, Polyzoa, and a few Otoliths of fish, with a good quantity of quartz sand; the Foraminifera were not common in quantity in this deposit, although twenty-two species were obtained.

Sounding 1. 27th June. Off NOSS HEAD, W. ¼ S. 27 miles. Depth, 70 fathoms.

Surface temperature, 50°·2; bottom temperature, 49°·2.

A gray sandy mud, containing many fragments of Gasteropod, Lamellibranch, and Echinoderm shells, with the following types of Foraminifera:—*Miliolina*, *Textularia*, *Uvigerina*,

Globigerina, *Truncatulina*, *Pulvinulina*, and *Rotalia*; none of the above forms were common.

Sounding 2. 29th June. SKERRY LIGHT, W. by N. 20 miles.
LUMBA NESS, N.W. ½ N. 18 miles. Depth, 55 fathoms.
Surface temperature, 50°; bottom temperature, 49°·9.

A yellow shell sand, composed chiefly of Gasteropod, Lamellibranch, *Dentalium*, *Serpulæ*, Polyzoa, and Echinoderm fragments, with quartz grains and Foraminifera, representing the following types:—*Biloculina*, *Miliolina*, *Spiroloculina*, *Textularia*, *Globigerina*, *Discorbina*, *Truncatulina*, *Pulvinulina*, and *Gypsina*; *Discorbina* and *Truncatulina* predominating.

Sounding 3. SKERRY LIGHT, W. ½ N. 27½ miles.
LUMBA NESS, N W. by N. 31 miles. Depth, 76 fathoms.
Surface temperature, 50°·2; bottom temperature, 50°.

A brown quartz sand with many fragments of Gasteropod and Lamellibranch shells, *Dentalium* tubes, Ostracod shells, *Serpulæ* tubes, Polyzoa, and Echinoderm fragments, the Foraminifera found in this deposit was similar to those taken in Sounding No. 2, but in greater quantities and variety among the bottom living forms.

Sounding 4. 1st July. FLOGER LIGHT, W. ¾ N. 29 miles.
Depth, 100 fathoms.
Surface temperature, 53°·4; bottom temperature, 49°·3.

A greenish ooze composed chiefly of pelagic and bottom-living Foraminifera, the most conspicuous genera being *Globigerina*, *Nonionina*, *Cassidulina*, and *Lagena*; the *Globigerina* were mostly of small Arctic variety *G. pachyderma*.

Sounding 5. 3d July. OSSA SKERRY, S.W. by S. ½ S. 7 miles.
UNA BASS, E.S.E., 5 miles. Depth, 56 fathoms.
Surface temperature, 54°; bottom temperature, 48°·6.

A fine shell sand, chiefly composed of very small shell

fragments with a few quartz, the same genera as in Sounding No. 4.

Sounding 6. 5th July. VE SKERRY, E. by N. 12 miles.
FOULA ISLAND, S. ½ W. 7 miles. Depth, 73 fathoms.
Surface temperature, 52°·3; bottom temperature, 51°·8.

A shell sand chiefly composed of fragments of Gasteropod and Lamellibranch shells with Ostracod, *Serpulæ*, Polyzoa, and Echinoderm fragments with a few quartz grains. The most conspicuous Foraminifera in this deposit were *Globigerina* (Arctic species), *Discorbina*, and *Truncatulina*.

Sounding 7. 6th July. FOULA ISLAND, N.W. 9 miles. Depth, 68 fathoms.
Surface temperature, 52°·2; bottom temperature, 51°·1.

A yellow shell sand from which only four genera of Foraminifera were taken, the most conspicuous being *Textularia*.

Sounding 8. 7th July. Lat. 59° 36′ N., Long. 2° 4′ W. Depth, 70 fathoms.

A quartz sand with a few shell fragments from which Foraminifera representing seven genera were taken, *Truncatulina* and *Discorbina* predominating.

Sounding 9. 8th July. SUMBURGH HEAD, E. ¾ S. 7½ miles.
FAIR ISLAND, S.W. ¼ S. 15 miles. Depth, 58 fathoms.

A yellow shelly sand from which Foraminifera of five genera only were taken all of the bottom-living species.

Sounding 10. 9th July. FAIR ISLAND, S. ¾ E. 14 miles.
SUMBURGH HEAD, E. by S. 12 miles. Depth, 62 fathoms.

This deposit was similar in every respect to Sounding No. 8.

Sounding 11, and washing from swabs. Lat. 58° 45′ N., Long. 0° 55′ 0″ E. Depth, 93 fathoms.

A blue sandy mud, with a few Gasteropod, Lamellibranch, and Ostracod shells, also many Echinoderm fragments. This deposit was exceedingly rich in Foraminifera, especially in the arenaceous type, notably *Astrorhiza arenaria*, *Haplophragmium*, and *Reophax*.

	Station No. 1.	Station No. 5.	Sounding No. 1	Sounding No. 2.	Sounding No. 3.	Sounding No 4.	Sounding No. 5.	Sounding No 6.	Sounding No 7.	Sounding No. 8.	Sounding No. 9.	Sounding No. 10.	Sounding No. 11.
Biloculina ringens (Lamk.), .	*	*		*									*
,, *depressa*, d'Orb., .	*					*	*						*
,, *elongata*, d'Orb., .													*
Miliolina seminulum (Linne.),	*		*	*	*	*	*			*	*	*	*
,, *trigonula* (Lamk.),								*					*
,, *bicornis*, W. and G.,				*	*								
,, *gracilis* (d'Orb.), .				*	*							*	*
,, *circularis*, Bornem.,													*
Spiroloculina limbata (d'Orb.),	*			*	*	*	*						
Psammosphæra fusca, F. E. Schulze, ...		* *			*								*
Astrorhiza limicola, Sandl., .													*
,, *arenaria*, Norman,													*
Rhabdammina cornuta, Brady,	*					*	*						*
Jaculella acuta, Brady, .	*					*	*	*					*
Hyperammina elongata, Brady,													*
Marsipella elongata, Norman,													*
Reophax fusiformis, Will.,													*
Haplophragmium canariensis (d'Orb.),		*			*								*
,, *tenuimargo*, Brady,	*					*	*						*
Ammodiscus incertus, d'Orb.,													*
Webbina clavata, P. and G., .						*							*
Textularia sagittula, Defr., .	*	*		*	*	*	*	*	*	*		*	*
,, *conica* (d'Orb.), .		*	*	*	*			*		*	*	*	*
,, *turris* (d'Orb.), .				*	*			*					*
,, *trochus* (d'Orb.), .				*						*			*
Bulimina marginata, d'Orb.,	*	*				*	*						*
,, *pyrula*, d'Orb., .	*					*	*						
,, *aculeata*, d'Orb., .													*
Bolivina beyrichi, var. *alata* (Seg.),	*					*	*						
,, *punctata*, d'Orb., .	*					*	*						*
Cassidulina crassa, d'Orb., .	*	*				*	*						*
,, *lævigata*, d'Orb.,	*	*				*	*						*
Lagena squamosa (Montag.), .	*					*	*						*
,, *sulcata* (W. and G.), .	*				*	*	*						*
,, *orbignyana*, Seg., .	*					*	*						
,, *striata* (d'Orb.), .	*					*	*						*
Polymorphina lactea (W. and J.)						*							

	Station No 1.	Station No. 5.	Sounding No. 1	Sounding No. 2	Sounding No. 3.	Sounding No. 4.	Sounding No. 5.	Sounding No. 6.	Sounding No. 7.	Sounding No. 8.	Sounding No. 9.	Sounding No. 10.	Sounding No. 11.
Polymorphina gibba, fistulose form, d'Orb.,		*											*
,, *sororia*, Reuss.,													*
,, *elegantissima*, P. and G., .		*											*
,, *communis*, d'Orb.,													*
Uvigerina angulosa, Will., .	*	*	*		*	*	*	*			*	*	*
,, *pygmaea*, d'Orb., .	*					*	*						
Globigerina bulloides, d'Orb.,	*	*	*	*	*	*	*	*					*
,, *pachyderma* (Ehren.)	*	*	*		*	*	*						*
,, *inflata*, d'Orb., .	*	*				*	*						*
,, (*Orbulina*) *universa*, d'Orb., .		*				*	*	*					*
Discorbina rosacea, d'Orb.,	*	*		*		*	*	*				*	*
,, *globularis*, d'Orb.,								*		*			*
,, *orbicularis* (Terq.),									*				
,, *vilardeboana* (d'Orb.)		*											*
Planorbulina mediterranensis d'Orb., ...									*	*		*	
Truncatulina lobatula (W. and G.), .	*	*	*	*		*	*	*	*	*	*	*	*
,, *refulgens* (Montf.)	*	*		*		*	*	*		*	*	*	*
Anomalina ammonoides (d'Orb.)	*					*	*						*
Pulvinulina Menardii, dwarfed (d'Orb.),	*					*	*						
,, *micheliniana* (d'Orb.)	*		*										*
,, *elegans* (d'Orb.), .	*	*	*	*		*	*			*			*
,, *auricula* (F. and M.),				*									
Rotalia beccarii (Linn.), .		*	*			*	*			*	*		*
Gypsina inhaerens (Schultze),				*					*				
Nonionina umbilicatula (Monta.)	*					*	*						*
,, *turgida* (Will.), .	*					*	*						*
,, *stellifera*, d'Orb., .													*

The following notes refer to species mentioned in the accompanying table, which present points of interest:—

Spiroloculina limbata.—Only one perfect specimen was found in Sounding No. 4, and a few fragmentary specimens in Soundings Nos. 2 and 3. So far as I am aware, it has never been found in this locality before.

Astrorhiza arenaria.—This interesting arenaceous Rhizopod was taken in considerable numbers, chiefly in a fragmentary state, in the deposit obtained from Sounding No. 11, and attached to swabs. It has never before been taken in this locality, or in such shallow water. Its nearest known habitat to the Scottish coast is the Faroe Channel, where it

was taken by the naturalists on board the "Knight Errant" in 530 to 650 fathoms.

Textularia turris, d'Orb.—Several dead specimens of this species were obtained in Soundings Nos. 2, 3, and 6, new to this locality.

Bolivina beyrichi, var. *alata*, Seg.—Several dead specimens were obtained from the material got from Station No. 4 and Sounding No. 4, new to British waters.

Polymorphina elegantissima, P. and G.—One specimen was found in the material from Station No. 5. This interesting species, according to Mr H. B. Brady, is confined to the Pacific Ocean; it is therefore worthy of note to have found an isolated specimen so far from its natural haunts.

Globigerina bulloides was taken by the surface nets often outside the Diatomaceous zones, covered with their delicate spines.

Discorbina orbicularis and *D. globularis* are also of interest, being found off the Shetland Islands.

The principal object of my accompanying the "Energy" was to investigate the habits and food of the herring, and whatever additional information I have obtained on this subject will present itself in the foregoing pages. The time was so short, and the difficulties with which I had to contend were such as to limit the information obtained. The most important point brought out by my cruise in the "Energy" is the necessity for continuous observations of a similar kind, but under better conditions. It seems to me that extremely valuable results would be obtained if a steam vessel, capable of remaining at sea for a few days at a time, were available for a purely scientific research on the natural history of the herring and other food fishes, which should visit all the principal fishing centres of Scotland. One season might be spent on the east coast, another on the west, and so on for a few seasons; and in this way much, if not all, the information so much sought for could be safely collected.

Special attention should be drawn to the following points:—(1.) The direction in which the herring are swimming when caught,—which is easily ascertained by finding the exact position in which the nets are lying; (2.) Collecting the pelagic

animals; (3.) Sounding and dredging; and (4.) the temperature of the water at intermediate depths from the surface downwards, all being carefully noted at each station. If this be carried out, there is no doubt that many more spawning-grounds and favourite haunts of the herring will be found. Finally, I here wish to express my indebtedness to Mr Murray for granting me leave to accompany the "Energy;" to Dr J. R. Henderson, who gave me great assistance in identifying many of the animals obtained; the Rev. Dr A. M. Norman, Dr Francis Day, Mr J. T. Cunningham, Dr James Rae, R.N., and Mr W. H. Shrubsole, for the ready help these gentlemen have given me; also the Managers of the Scottish Sea Fishing and Curing Company (Limited), and to Captain J. Tulloch and crew of the "Energy," who were always ready to give me every assistance in their power.

XXXIII. *On some New or Little-Known Fossil Lycopods from the Carboniferous Formation.* By ROBERT KIDSTON, Esq., F.G.S. [Plate XXI.]

(Read 18th March 1885.)

The following notes are offered as a small contribution to our knowledge of the Carboniferous flora of Britain. Several of the specimens now about to be described have been known to me for a considerable length of time, but various causes have contributed to delay their publication.

1. *Sigillaria McMurtriei,* Kidston, n. sp.
2. *Sigillaria coriacea,* Kidston, n. sp.
3. *Sigillaria Walchii,* Sauveur.
4. *Lepidodendron Peachii,* Kidston, n. sp.

1. *Sigillaria McMurtriei,* Kidston, n. sp. (Pl. XXI., Figs. 3-5).

Description.—Leaf-cushion rhomboidal, with the upper and lower angles truncated, giving it a hexagonal appearance, elevated; from the leaf-scar downwards runs a flattened area, which bears a slightly raised medial line; surface of the

cushion ornamented with fine granulations placed in irregular lines and more prominent on the lower part of the cushion. Leaf-scar situated on the upward-directed elevated summit of the cushion, elongated, rhomboidal; lateral angles prominent and produced, the lower angle rounded, the upper rounded, with a slight sinus. Vascular cicatricules three, the two lateral oval and directed outwards, the central transversely linear and placed below the centre of the lateral cicatricules.

Remarks.—This species of *Sigillaria* in some of its characters has a superficial resemblance to both *Lepidodendron* and *Lepidophloios.*

Figures 3 and 5 have very much the appearance as if the leaf-scar were surrounded by a "*field,*" as in *Lepidodendron;* but the apparent "*field*" is merely a cortical extension, similar to the leaf-cushions in the Clathrarian *Sigillariæ*, and only differing from the other members of this group of *Sigillaria* in its more highly developed condition.

On the lower part of the cushion occurs a flattened area, which runs from the lower rounded angle of the leaf-scar to the base of the cushion. In the centre of this band is a very gently raised line, from each side of which, at an almost imperceptible angle, slope the two sides of this flattened area. The surface of the cushion is ornamented with irregular granulations, which appear to be roughly arranged in lines springing from its base.

The extent to which the cushions are elevated is shown in the vertical sections, Figs. 3*a*, 4*a*, and 5*a*, which respectively represent sections of cushions and leaf-scars from specimens drawn at Figs. 3, 4, and 5. From the examination of this part of the fossil it is evident that we are dealing with a cortical extension similar to the leaf-cushions of the Clathrarian *Sigillariæ*, and not with the "field" of a Lepidodendroid leaf-scar.

The much-elevated cushions in *Sigillaria McMurtriei* have a considerable resemblance to those of *Lepidophloios;* but the character which at once proves this plant to be a true *Sigillaria*, and not a *Lepidophloios*, is the form of the vascular cicatricules. Of these the two lateral are linear-oval, the central transversely elongated and placed below the centre of

the lateral cicatricules. In some cases the central cicatricule appears to be composed of two points placed closely together (Fig. 3*b*). A form and arrangement of the vascular bundle cicatricules such as that just described occurs only in the genus *Sigillaria*.

From the epidermal ornamentation of the cushions it is also clear that the leaf was not attached to any part of its surface, but to the vascular scar alone.

This last character is of itself sufficient to exclude the plant from *Lepidodendron* and restrict its relationship to *Lepidophloios* or *Sigillaria;* but, as already indicated, the vascular cicatricules are Sigillarian, and not those of *Lepidophloios,* and, in fact, there is here only a Clathrarian *Sigillaria* with highly developed leaf-cushions.

Of the three figures which I give of this plant, Figs. 3 and 5 must be regarded as representing the typical form.

On all the specimens the leaf-scar is of the same shape, but the slight sinus in its upper margin is sometimes very feebly developed.

In Fig. 3 the ornamentation is more strongly marked on the portion of the leaf-cushion below the leaf-scar than on the part above it; in Fig. 5 the ornamentation covers more equally the whole surface of the cushion.

In Fig. 4, on the other hand, the ornamentation is very slightly represented; so little is it shown that it can scarcely be said to be present. Although on this specimen the leaf-scars are larger and their cushions more elevated than in Figs. 3 and 5 (see Fig. 4*a*), it probably represents a younger state of the plant, which, when older, would have the cushions more drawn out as in Fig. 5.

As Figs. 3, 4, and 5 are drawn of the natural size, it is scarcely necessary to give the measurements of the leaf-scars and their cushions; these also vary considerably with the age of the specimen. In all cases the leaf-scar is broader than high.

In the decorticated condition the surface of the stem is roughened by an irregular small mesh-like granulation, which is more or less arranged in vertical lines (Fig. 5, part marked *a*).

The only species to which *Sigillaria McMurtriei* has any resemblance is *Sigillaria tumida*, Bunbury, sp. (*Lepidodendron? tumidum*, Quart. Journ. Geol. Soc., vol. iii., p. 432, pl. xxiv., fig. 1). From this species it differs in the form of its leaf-cushions. The surface-ornamentation in *Sigillaria tumida* also differs in being "rather irregular, wavy, longitudinal striæ."

Bunbury described his plant as *Lepidodendron? tumidum*, and Schimper places it in *Lepidophloios*;[1] but I believe that this plant is also a *Sigillaria*.

In his description Bunbury does not mention the form of the lateral cicatricules, nor does his drawing show it very clearly; but he says the central cicatricule consists of "two vascular points placed close together and often confluent."

In some of the leaf-scars of *Sigillaria McMurtriei* there is the same appearance in the central vascular cicatricule (see Fig. 3*b*). A similar structure occurs in the vascular impression of *Sigillaria Lorwayana*, Dawson.[2]

In *Sigillaria Moureti*, Zeiller,[3] a somewhat similar structure of the vascular cicatricule also occurs.

I have entered very fully into the description of *Sigillaria McMurtriei* to show that it is a true member of the genus *Sigillaria;* and from the great similarity of *Lepidodendron? tumidum*, Bunbury, to *Sigillaria McMurtriei* in all general points, I think there cannot remain any doubt as to its also being a Clathrarian *Sigillaria*. Bunbury himself expresses his difficulty in regard to the position of his plant, and says that it would be referred by some to *Lepidodendron*, and by others to *Sigillaria*.

I first observed this species in the collection of Mr J. McMurtrie, Radstock, after whom I have great pleasure in naming it. Mr McMurtrie has not only carefully collected the fossil plants of the Radstock Coal-field, but has done much to elucidate the geology of his neighbourhood. I also

[1] Schimper, Traité d. paléont. végét., vol. ii., p. 52.

[2] Dawson, "Fossil Plants of Lower Carboniferous and Millstone-Grit Formations of Canada," p. 48 (woodcut), 1873.

[3] Zeiller, Bull. Soc. Géol. de France, 3e sér., vol. viii., p. 210, pl. v., fig. 3.

take this opportunity of expressing my thanks to him for much valuable assistance received while examining the fossil flora of the Radstock Coal-field.

Horizon. Radstock Series of the Upper Coal-measures.

Locality. Tyning Pit, Radstock, Somersetshire.

2. *Sigillaria coriacea,* Kidston, n. sp. (Pl. XXI., Fig. 2).

Description.—Ribs alternately widening and contracting; leaf-scars placed on the dilations, wider than high, with a slight sinus on their upper margin; lateral angles prominent, situated about the centre of the scar, with downward-running ridges; vascular cicatricules placed above the middle of the leaf-scar, the two lateral lunate, the central punctiform. Outer surface of the bark ornamented with a fine granulation.

Remarks.—The only specimens of this fine *Sigillaria* with which I am acquainted are those in the British Museum, which became known to me while preparing the "Catalogue of the Palæozoic Plants" in that collection. All the specimens represent a similar age of the plant, and perhaps are different pieces of one individual.

The ribs measure across the dilated portions 22 millim., and at the constrictions 19 millim. The leaf-scars are 16 millim. broad and 12 millim. high, and 16 millim. apart.

The whole surface of the bark is ornamented with a fine granulation. On the central portion of the ribs it is more strongly marked and the granulation slightly larger than on the other portions of their surface; but its presence is distinctly seen over the whole area of the ribs.

The two lunate vascular impressions are 3 millim. long, and the central punctiform cicatricule is about 1 millim. in diameter. The sinus on the upper margin of the leaf-scar, though slight, is distinct.

The ornamentation of the bark is of a somewhat similar nature to that which occurs on *Sigillaria duacensis,* Boulay,[1] but much finer. From this species it differs entirely in the

[1] Boulay, "Le terr. houil. du nord de la France et ses végétaux fossiles," p. 43, pl. ii., fig. 3. Thèse de géologie présentée à la Faculté des Sciences de Caen: Lille, 1876.

form of the leaf-scar and the position of the vascular cicatricules, which are central in *S. duacensis,* while those of *Sigillaria coriacea* are placed above the centre.

The specimens, unfortunately, do not bear any note of the locality from which they were collected; but from indirect evidence there is every reason to believe that they came from the Newcastle-on-Tyne Coalfield.

The figure (Pl. XXI., Fig. 2) is taken from a plaster cast of an impression of the plant in the British Museum. My thanks are due to Dr H. Woodward, F.R.S., for permission to describe this species.

Horizon. Coal-measures.

Locality. (?) Newcastle-on-Tyne, Northumberland.

3. *Sigillaria Walchii,* Sauveur (Pl. XXI., Fig. 1).

Sigillaria Walchii, Sauveur, Végét. foss. d. terr. houil. de la Belgique, pl. lvii., fig. 3;[1] Boulay, Terr. houil. du nord de France et ses végét. foss., p. 43.

Description.—Ribs wide, smooth; leaf-scars separated by a short interval, subtriangular, as broad as high, the upper angle obtusely rounded, the lateral angles placed below the centre, rounded, but distinct, the lower margin indented by a slight sinus; vascular cicatricules situated above the centre, the two lateral lunate, the central punctiform. On the ribs immediately above the leaf-scar is a slightly bent transverse furrow. The decorticated stem is finely striated longitudinally.

Remarks.—In the specimen figured on Pl. XXI., Fig. 1, the ribs are 20 millim. broad; the leaf-scars, of pyriform outline, are 10 millim. in height and the same in breadth; they stand about 4 millim. apart. The slightly lunate transverse furrow which surmounts them is about 10 millim. long. The outer surface of the bark is quite smooth.

The elevation of the ribs is shown at Fig. 1*b*. They are flat, but, from the perfection with which the leaf-scars are preserved, I am inclined to think that the fossil has suffered little from pressure.

[1] Académie royale des sciences, des lettres et des beaux-arts de Belgique, 1848.

This example agrees in all respects with the figure given by Sauveur (without description), and that described by Boulay, except that neither of these authors notes the occurrence of the transverse furrow above the leaf-scar; but the specimens examined by these writers do not appear to have been very well preserved.

Boulay mentions, in his description, that in his fossil the cicatricules were badly preserved; and from the slight haziness which pervades Sauveur's figure, one is also led to conclude that neither was it in a very good state of preservation.

The ribs on the Scotch specimen are broader in proportion to the size of the leaf-scars than in the foreign examples; but this character is evidently dependent on the age of the plant. I have observed in specimens of *Sigillaria lævigata*, Brongniart, that, though the ribs with age increase much in width, the leaf-scars undergo little or no enlargement; hence the relative size of the leaf-sear to the width of the rib appears to be of very little specific value. The distance of the leaf-scars apart is also subject to much variation, even on the same specimen.

Sigillaria Walchii appears to be rare in Britain. The only example I have as yet seen was communicated to me for examination by Mr J. Smith, Kilwinning, to whose courtesy I am indebted for the addition of this species to our Carboniferous fossil flora.

Horizon. Coal-measures; roof of turf-coal.

Locality. Kilwinning, Ayrshire.

4. *Lepidodendron Peachii*, Kidston, n. sp. (Pl. XXI., Fig. 6).

Description.—Leaf-scars rhomboidal, the boundary lines of the upper part of the leaf-scar convex, those of the lower part concave, lateral angles prominent. Vascular impression slightly above the middle, rhomboidal, transversely elongated; from its lateral angles extends a raised line to the centre of the lateral angles of the leaf-scar, dividing the "field" into an upper and a lower portion. The upper part of the leaf-scar is slightly more elevated than the lower portion, which causes it to rise above the vascular impression in a hood-like manner. Vascular-bundle cicatricules three, punctiform.

Remarks.—The figure shows on each side of the main stem the remains of a small branch; these are so much narrower than the stem which bears them that they give the fossil an appearance as if it possessed a lateral ramification, but these small branches are evidently the result of an unequally developed dichotomy. On a specimen of this plant from Newsham the same characteristic is exhibited.

On none of the few examples of *Lepidodendron Peachii* which I have seen, are the two little oval depressions shown, which in well-preserved Lepidodendroid leaf-scars are usually exhibited, one on each side of the median line immediately below the vascular impression; but their absence may be due to imperfect preservation.

Lepidodendron Peachii has a slight resemblance to *Lepidodendron Rhodeanum,* Sternberg; but in *Lepidodendron Peachii* the lateral angles are more prominent and the upper extremity of the scar much more rounded. The vascular impression is also more central and its angles more prominent.

The point, however, which at once separates this species from *Lepidodendron Rhodeanum* is the elevation of the upper portion of the leaf-scar. This is seen in profile at Fig. 6*b*. This peculiar inflation imparts to the leaf-scar a characteristic appearance, which at once distinguishes *Lepidodendron Peachii* from any other species of *Lepidodendron* with which I am acquainted.

Lepidodendron Peachii is also related to *Lepidodendron minutum,* Sauveur,[1] and *Lepidodendron Andrewsii,* Lesquereux.[2]

The figure given by Sauveur of his *Lepidodendron minutum* shows a fragment of a stem rather less than 2 inches long and about three quarters of an inch wide. The leaf-scars are about 4 millim. long and of about the same width; in outline some of them are hexagonal, especially towards the lower part of the figure. Notwithstanding, however, the general similarity of *Lepidodendron minutum* to *Lepidodendron Peachii,* without further evidence than that afforded by

[1] Sauveur, "Végétaux fossiles d. terr. houil. de la Belgique," pl. lxi., fig. 3 (1848).

[2] Lesquereux, "Coal Flora of Pennsyl.," p. 389, pl. lxiv., fig. 6 (1880).

Sauveur's figure, which is unaccompanied by a description, it is quite impossible to identify the Scotch specimen as his plant.

Another example of *Lepidodendron Peachii* from Newsham, Northumberland, showing a younger branch on which the leaf-scars are smaller than on the Falkirk specimen, has also a like similarity with *Lepidodendron minutum*, but the objections mentioned in regard to the identification of the Falkirk fossil with Sauveur's species also apply to this.

The type of *Lepidodendron Andrewsii* is also fragmentary, and scarcely affords sufficient characters for a satisfactory comparison. Lesquereux says of his species, that "it is of the type of *Lepidodendron Volkmannianum*," to which group *Lepidodendron Peachii* can scarcely be said to belong.

The specimen which forms the type of this species was collected in 1870 by Mr C. W. Peach, who some time ago submitted it to me for examination; but owing to the difficulty in identifying specimens of *Lepidodendron* with many of the described species without the opportunity of examining the types, it has been allowed to remain over till the present time. I have great pleasure in naming this plant after its discoverer, to whom I owe so deep a debt of gratitude for willing assistance given me in my study of the British Palæozoic fossil flora.

Horizon and Localities. Scotland: Coal-measures; Brick-works, Falkirk, Stirlingshire. England: Middle Coal-measures (low-main seam); Newsham, Newcastle-on-Tyne, Northumberland.

Explanation of Plate.

Fig. 1. *Sigillaria Walchii*, Sauveur. From the roof of the turf-coal, Kilwinning (nat. size). 1*a*. Leaf-scar, enlarged 1½ diameters. 1*b*. Section of specimen, showing elevation of ribs. Original in the possession of Mr J. Smith, Kilwinning.

Fig. 2. *Sigillaria coriacea*, Kidston, n. sp. From (?) Newcastle-on-Tyne. Figure taken from plaster cast of specimen in the collection of the British Museum. (Nat. size.)

Figs. 3-5. *Sigillaria McMurtriei*, Kidston, n. sp. From Tyning Pit, Radstock, Somersetshire (nat. size). 3. Figure taken from plaster cast of impression in the author's collection. Communicated by Mr J. McMurtrie,

Radstock. 3*a*. Vertical section of one of the cushions (*a* indicates position of leaf-scar, *b* its supporting cushion). 3*b*. Leaf-scar, enlarged 1½ diameters, to show the vascular cicatricules, the central of which is composed of two confluent dots. 4. Figure from plaster cast of an impression in the collection of Mr McMurtrie. 4*a*. Vertical section of one of the cushions. 5. Four cushions with their associated leaf-scars, from a specimen in the author's collection. Communicated by Mr J. McMurtrie. The part marked *a* shows the decorticated condition. 5*a*. Vertical section of one of the cushions.

Fig. 6. *Lepidodendron Peachii*, Kidston, n. sp. From the Brickworks, Falkirk, Stirlingshire (nat. size). Original in the collection of Mr C. W. Peach. 6*a*. Leaf-scar, enlarged 2 diameters. 6*b*. Leaf-scar, shown in profile, enlarged 2 diameters.

XXXIV. *Note on the Paired Dorsal Vessel of Certain Earthworms.* By F. E. Beddard, Esq., M.A., F.Z.S., Prosector to the Zoological Society of London. [Plate XXII.]

(Read 20th May 1885.)

In studying the anatomy of several new forms of earthworms that I have lately received from New Zealand by the kindness of Professor T. J. Parker, I noted the fact that in certain of them the dorsal trunk of the vascular system is represented by two trunks, more or less completely separate from each other. This fact is of some interest, because it is known that the single dorsal vessel of *Lumbricus* is represented in the embryo by two rudiments, which only subsequently coalesce. This fact we owe to the researches of Kovalevsky;[1] Vejdovsky has more recently extended the discovery to *Criodrilus*, and has published a brief account of his observations in a preliminary note addressed to the Bohemian Academy.[2] The two rudiments of what is subsequently to become the unpaired dorsal vessel of the adult *Criodrilus* are situated above, and rather to the side of, the intestine; their position in fact would appear to correspond very closely to the lateral vessels, or intestino-tegumentary trunks as Perrier has termed them, which are found in *Lumbricus* and in many other genera of earthworms, but do not seem to be repre-

[1] Mem. d. l'Acad. de St Petersb. 1871. [2] S. B. Böhm. Acad. 1879.

sented in the *Oligochæta limicola;* in later stages of development these two rudiments get nearer together, and finally coalesce on the dorsal median line of the intestine. Vejdovsky has pointed out in this paper that the developmental history of the dorsal vessel in *Criodrilus* seems to have some significance, because it is known that the dorsal vessel of *Hermella* is *persistently* double. The anatomy of this worm, especially the circulation, has been described by De Quatrefages[1] in a beautifully illustrated memoir; the dorsal vessels—together homologous with the unpaired vessel of other genera—retain their distinctness throughout the greater part of the body, though connected here and there by transverse vessels; at the junction of the œsophagus with the crop the two trunks unite and form a single vessel, which runs along the œsophagus to the anterior end of the body. De Quatrefages' figures are repeated in the illustrated edition of Cuvier's "Regne Animale," which contains figures of the circulatory system of other Polychaetous Annelids; in several of these the dorsal vessel resembles that of *Hermella* in being double; in *Terebella conchilega* (Pl. 1*c*, Fig. 1) the two dorsal trunks lie quite at the sides of the intestine as they do in *Hermella*, but unite to form a single vessel at the junction of the œsophagus with the intestine; in *Eunice sanguinea* (Pl. 1*a*, Fig. 2) the dorsal vessel is double, but differs in that the two trunks are placed close together, apparently almost in contact, on the dorsal side of the intestine; on the œsophagus the vessel is single. Dr Macintosh, in his elaborate memoir on the structure of *Magelona*,[2] and also in a special notice of the vascular system of the same Annelid published in a recent volume of the Journal of Anatomy,[3] has described a dorsal vessel which is formed of two distinct and separate tubes placed close together as in *Eunice*, only divided by a narrow septum: in the anterior part of the body, as in all the other genera referred to, the two trunks unite. In the cases just mentioned, it is interesting to note that in the "Sedentary" Annelids, the two dorsal vessels resemble the two nerve

[1] Ann. Sci. Nat., ser. 3, t. x., pl. ii., fig. 1.
[2] Zeitschr. f. wiss. Zool., Bd. xxxi.
[3] Vol. xiv.

trunks in being widely separated; in *Eunice* and *Magelona* the two halves of the nerve cord as well as the two dorsal vessels are close together.

The fact of the development of the dorsal vessel of *Criodrilus* and *Lumbricus* from two tubes gains additional significance from a comparison with other groups of the animal kingdom. Claus has recorded that the heart of *Apus* arises from two lateral rudiments; and in *Geophilus* Metchnikoff[1] has stated that the heart originates in a similar fashion; there can be but little doubt that the heart in the Arthropoda, together with its anterior and posterior aorta, is equivalent to the dorsal trunk of the vascular system of worms. Without giving a complete list of those Arthropoda in which the heart has a similar origin, it is worth while to refer to an account by Dr Jaworovsky[2] of the development of the heart in *Chironomus;* in this insect the heart appears to arise from two separate rudiments, which finally coalesce, but retain a remarkable physiological independence, the one from the other, which expresses the morphological distinctness of the two sides of the heart; the contraction of the heart has been shown by Jaworovsky to be carried out independently of each other by each of its two sides, so that although the organ is in the adult only a single cavity, it bears unmistakable traces of having originated from a paired vessel; such a physiological demonstration of a morphological fact is of the highest interest. If the old idea of Geoffroy St Hilaire that the "ventral" surface of an Annelid is homologous with the "dorsal" surface of a vertebrate, be confirmed by future researches—and there is at present evidently a great deal to be said in favour of this view—then there is at least some reason for supposing that the heart of the vertebrate has been developed out of the dorsal vessel of its Annelid ancestor; in any case the relation of both to the intestine would be the same, and the transverse trunks which connect the dorsal with the ventral blood vessel in an Annelid have an obvious resemblance to the aortic arches of a vertebrate; moreover, we know that the earliest rudiment of the heart

[1] Zeitschr f. wiss. Zool., Bd. xxv., p. 318.

[2] S. B. Akad. Wiss. Wien., Bd. 80, Abth. i., 1880, p. 238.

in mammals, birds, and Teleosteans is paired, and there is therefore a further similarity with the dorsal vessel of *Lumbricus*. Balfour, however, in his "Comparative Embryology," is disinclined to admit that the origin of the vertebrate heart as a double tube has any phylogenetic significance; he gives reasons for believing "that the formation of the heart as two cavities is a secondary mode of development, which has been brought about by variations in the period of the closing in of the wall of the throat." Quite recently this statement of opinion has been controverted by Schimkewitzsch,[1] who declares that the origin of the vertebrate heart from two rudiments *is* a primitive mode of development.

I am unacquainted with any instance of a double dorsal vessel in the *Oligochæta limicola*, but it is characteristic of many earthworms. Two years ago I described in the *Transactions*[2] of the Royal Society of Edinburgh the anatomy of an earthworm which at that time was believed to be a new genus, but which has since turned out to be identical with Templeton's *Megascolex cœruleus*;[3] in that earthworm the dorsal vessel has retained to a certain extent the embryonic character; instead of being a single tube passing from end to end of the body as in *Lumbricus*, the anterior portion of the dorsal vessel is partially divided into two separate tubes; this occurs in five of the anterior segments (apparently 4-8 inclusive); the two halves of the dorsal vessel are not entirely separate from each other, but reunite at the point where the vessel traverses the mesenteries which are interposed between the several segments; behind the eighth segment the dorsal vessel becomes a single trunk, and is continued without any alteration in its character to the posterior extreme of the body.

So far as I am aware *Megascolex* is the only genus of earthworms in which this condition of the dorsal vessel has been recorded. I take this opportunity of bringing together a few other instances in which I have recently noticed a similar state of affairs.

In a large earthworm from Natal, belonging to quite another genus (*Microchaeta*), and differing in many essential characters

[1] Zool. Anzeig., No. 186 (1885), p. 40. [2] Vol. xxx., pt. ii., p. 481.
[3] Ann. and Mag. Nat. Hist., May 1884, p. 398.

from *Megascolex*, the peculiar disposition of the dorsal vessel was almost exactly repeated; in five of the anterior segments of the body the dorsal vessel is separated into two distinct tubes, which lie widely apart in the cavity of the segments which they occupy, but reunite before perforating the mesenteries; the transverse trunks or "hearts," as they have been termed, which unite the dorsal with the ventral blood vessel, arise in every case from the unpaired portion of the dorsal vessel, close to the posterior mesentery of their segment; after the tenth segment the dorsal vessel becomes single. The accompanying figure will illustrate this point (Pl. XXII., Fig. 1). In both these instances cited it is only the most anterior section of the dorsal vessel which has retained its original paired condition. This, however, is not always the case; there are other earthworms which retain much more completely than either of these two, the original paired dorsal vessel. The collection of earthworms from New Zealand already referred to prove to belong to three distinct species, probably referable to Perrier's genus *Acanthodrilus*;[1] in two of these *the dorsal vessel is formed of two separate tubes, which run close together from end to end of the body*, only uniting upon the pharynx.

There is some difference in detail: in one species the structure of the dorsal vessel in the anterior region of the body is precisely similar to that which has been already described in *Megascolex*; the two vessels unite at the point where they traverse the mesenteries, but in the interior of each segment become very widely separated. Contrary to what is found in *Megascolex*, the dorsal vessel has the same structure throughout its whole extent; in each segment of the body the two dorsal vessels are completely separate, but unite at their passage through the mesenteries; the vessels being naturally injected with their own blood, it was easy to ascertain that this was really the case, which was also proved by transverse sections; it is rather remarkable to find that in another species closely allied to the foregoing, only differing in very trivial characters, but still distinct, the dorsal vessel does not exhibit the same embryonic character.

[1] Archives d. Muséum, t. vii.

In the third species, which is very different in its anatomical as well as external characters from either of the two described above, the dorsal vessel was still more completely separated into two distinct tubes; these only united together to form a single trunk upon the gizzard, which in this as in so many other earthworms is situated close behind the pharynx, and not at the junction of the œsophagus with the crop as is the case with *Lumbricus*. The two dorsal vessels appeared to pass to the posterior extreme of the body without being connected by any anastomoses or transverse vessels; in traversing the mesenteries they also retained their distinctness, and were not fused together at these points as in the last-mentioned species. In this earthworm, therefore, the dorsal vessel retains its (presumably) embryonic character much more completely than in any of the other three species to which I have referred above. I should add that, in every case, the results recorded do not depend upon the dissection of a single individual, but upon two or more; they are not, therefore, likely to be abnormal.

The above described facts are illustrated in the two drawings which I exhibit (Pl. XXII., Figs. 2, 3). Fig. 2 is a sketch of the circulatory system in the anterior part of the body, from which the lateral trunks as well as the peripheral circulation generally has been omitted in order to avoid undue complication. I may, however, take the opportunity of calling attention to some other facts in the circulatory system of *Acanthodrilus*, of which there are no published descriptions. The dorsal vessel is connected directly with the ventral vessel by eight pairs of transverse trunks, of which the five anterior spring from the dorsal vessel itself; the three posterior pairs, which are considerably larger and stouter than the anterior, spring not from the dorsal vessel itself but from a small trunk which lies beneath it and immediately upon the intestine; this vessel has been termed by Perrier the supra-intestinal, and its connection with the posterior "hearts" has been recorded to exist in many other genera of earthworms;[1] in the second species of *Acanthodrilus* to which I have referred in the present paper, the arrangement of the

[1] Arch. de Zool. Exp., t. iii., t. ix.

supra-intestinal vessel and lateral hearts is practically identical with that just described, except that the two halves of the dorsal vessel do *not* unite together at the point where they traverse the mesenteries. Fig. 3 represents a small portion of the intestine, together with the dorsal vessels and the principal branches, of which there are two pairs in each segment; one pair is given off close to the mesentery, and is concerned with its blood supply, while the other exclusively supplies the intestinal walls.

Fig. 1 is an illustration of the principal trunks of the vascular system in *Microchæta*, and it will be observed that in this earthworm as in *Lumbricus* all the hearts are given off directly from the dorsal vessel.

Explanation of Plate.

d = Dorsal vessel.
v = Ventral vessel.
s.v. = Supra-intestinal vessel.
h = Heart.
m = Mesentery.

Fig. 1. Circulatory system of *Microchæta* in anterior part of body.
Fig. 2. Circulatory system of *Acanthodrilus*, sp.
Fig. 3. A small portion of the intestine of a second species of *Acanthodrilus*, showing the completely double dorsal vessel.

XXXV. *Notes on the Birds of the Island of Eigg.* By William Evans, Esq., F.R.S.E.

(Read 21st January 1885.)

The list of the birds of the island of Eigg, which I propose laying before the Society this evening, has been prepared under the following circumstances.

Being desirous to gain some knowledge, from personal observation, of the habits of the Manx shearwater at one of its breeding stations, as well as to obtain with my own hands a specimen of its egg, I landed on the island on the afternoon of the 19th of June last,—having crossed from Arasaig in a fishing-boat,—and remained till the morning of the 24th June, when I left in the ss. "Claymore" for Oban.

When I went to Eigg I had no intention of making a list

of its birds, the object of the visit being solely to make the acquaintance of the shearwaters on their breeding grounds, and to them, therefore, the greater part of the short time at my disposal was devoted. A note was carefully taken, however, of every species I chanced to come across, and on showing these memoranda to our Secretary on my return, he was good enough to suggest that they might be of interest to the Fellows of the Society. Had I thought when at Eigg of making such a communication, I would have endeavoured to explore more thoroughly certain parts of the island to which I gave but a cursory glance, such, for instance, as the grounds and plantations around Professor Macpherson's residence, where not a few interesting woodland species would doubtless have been met with. Through the kindness, however, of Mr J. J. Dalgleish of Glenborrodale Castle, Ardnamurchan; Mr Robert Gray, the Society's Secretary; and Mr G. Scott, Professor Macpherson's manager on the island,—to all of whom I take this opportunity of conveying my best thanks,—I am enabled to include in the list the species likely to have been overlooked, and doubtless many others also, as well as to submit corroborative evidence of a large part of my own observations. The sources of information to which I refer are:—

1. Extracts in the possession of Mr Gray from Journal kept by Dr A. C. Stark, Eastbourne, Sussex, who landed on the island in April 1879.
2. MS. list by Mr J. J. Dalgleish of the birds observed by him on the island in the end of May and beginning of June 1879.
3. Supplementary list sent to Mr Dalgleish in January 1880 by Mr A. F. Joass, Contractor, Dingwall (brother of the Rev. Dr Joass of Golspie), of species not in No. 2, which he had observed in the course of frequent visits to the island during the five years 1875-79.
4. Communications, both verbal and by letter, to myself from Mr Scott, Professor Macpherson's manager.

Of published material there is not much to refer to. A quaint reference to the solan goose in Dean Munro's account

of his visit to the Hebrides in 1549; a notice (evidently borrowed from the above) of the same bird, in a description of Scotland by J. Monipennie, 1612; a passing allusion to the eagle and the puffin (shearwater) in Hugh Miller's "Cruise of the Betsey," 1859; some eight or nine references in Gray's "Birds of the West of Scotland," 1871; a note by the last-named author, on the shearwaters, in the *Proceedings* of this Society for Session 1877-78; and a few interesting observations communicated to the *Zoologist* in November 1882 by the Rev. H. A. Macpherson of Glendale, Skye, are all that I have been able to find. As far as I can discover, neither M. Martin nor James Wilson says anything about the birds that may have been seen on Eigg when they respectively visited it in the course of their celebrated peregrinations among the Western Isles.

The annexed list includes eighty-four species, fifty of which were observed by myself. The list, in which residents and summer visitants predominate, is of course very far from being a complete one, and would be largely added to by any competent ornithologist resident on the island during winter and at the periods of the spring and autumn migrations. Such local lists, although incomplete, are nevertheless of value, as far as they go, in enabling us to determine with greater accuracy the precise areas of distribution of individual species, and in affording the means of comparison with future observations; and it is in the hope that these notes may be of some such service that I venture to bring them before you.

List of Species.

1. *Aquila chrysaëtos* (Golden Eagle).—A male golden eagle was seen by Dr Stark on 24th April 1879 flying about the island. Dr Stark remarks that this and the next species come from Rum, where they breed, to hunt for rabbits. The rabbit and the brown rat are, I am informed, the only quadrupeds in a wild state on Eigg.

2. *Haliaëtus albicilla* (White-tailed Eagle).—Occasionally comes over from Rum and Skye. In Gray's "Birds of the West of Scotland," published in 1871, the Scuir of Eigg is mentioned as a breeding station; and the Rev. H. A. Mac-

pherson states that on 21st May 1882 he saw "the deserted eyrie of the sea eagles that until lately bred in Eigg" (*vide Zoologist* for 1882, p. 420). I have been at some pains to discover when the eagles last bred in the island, and have ascertained that none have done so since 1877, when a pair nested in the rocks above Cleadale.

3. *Falco peregrinus* (Peregrine Falcon).—A pair were observed by me, frequenting the cliffs in the north-east part of the island. From the manner in which they circled around, continually uttering their shrill cries, it was evident they had a brood in the rocks. Dr Stark mentions two eyries.

4. *Falco tinnunculus* (Kestrel).—Several seen: observed also by Mr Dalgleish. Appears to be the commonest bird of prey on the island.

5. *Accipiter nisus* (Sparrow-Hawk).—Occasionally seen by Mr Scott, who knows the species well.

6. *Buteo vulgaris* (Common Buzzard).—A pair were seen close to the haunt of the peregrines, and, from their behaviour, were evidently nesting there also. The marked differences in the flight and the cry of the two species were observed to great advantage. A pair of buzzards are also referred to in Stark's notes.

7. *Otus brachyotus* (Short-eared Owl).—Included in Dalgleish's list on Scott's authority. From a conversation I had with Mr Scott on the subject, I am convinced of the accuracy of this record; and I am inclined to think that the long-eared owl also occurs on the island.

8. *Strix flammea* (Barn Owl).—While talking to Mr Scott at the door of his cottage at dusk on the 22d of June, an owl flew past, which I felt sure was a barn owl. White owls are well known to Mr Scott, and Mr Joass also mentions having seen them.

9. *Muscicapa grisola* (Spotted Flycatcher).—Seen by Mr Dalgleish in bushes below the shearwater rocks at Laig.

10. *Cinclus aquaticus* (Common Dipper).—Observed by Mr Dalgleish; also by the Rev. Mr Macpherson, on a rivulet at Laig.

11. *Turdus musicus* (Song Thrush).—I saw several; and found a nest containing four fresh eggs. This nest was placed on the side of a ditch in a bleak part of the island, and was sheltered by a bush of tall heather.

Radstock. 3*a*. Vertical section of one of the cushions (*a* indicates position of leaf-scar, *b* its supporting cushion). 3*b*. Leaf-scar, enlarged 1½ diameters, to show the vascular cicatricules, the central of which is composed of two confluent dots. 4. Figure from plaster cast of an impression in the collection of Mr McMurtrie. 4*a*. Vertical section of one of the cushions. 5. Four cushions with their associated leaf-scars, from a specimen in the author's collection. Communicated by Mr J. McMurtrie. The part marked *a* shows the decorticated condition. 5*a*. Vertical section of one of the cushions.

Fig. 6. *Lepidodendron Peachii*, Kidston, n. sp. From the Brickworks, Falkirk, Stirlingshire (nat. size). Original in the collection of Mr C. W. Peach. 6*a*. Leaf-scar, enlarged 2 diameters. 6*b*. Leaf-scar, shown in profile, enlarged 2 diameters.

XXXIV. *Note on the Paired Dorsal Vessel of Certain Earthworms.* By F. E. BEDDARD, Esq., M.A., F.Z.S., Prosector to the Zoological Society of London. [Plate XXII.]

(Read 20th May 1885.)

In studying the anatomy of several new forms of earthworms that I have lately received from New Zealand by the kindness of Professor T. J. Parker, I noted the fact that in certain of them the dorsal trunk of the vascular system is represented by two trunks, more or less completely separate from each other. This fact is of some interest, because it is known that the single dorsal vessel of *Lumbricus* is represented in the embryo by two rudiments, which only subsequently coalesce. This fact we owe to the researches of Kovalevsky;[1] Vejdovsky has more recently extended the discovery to *Criodrilus*, and has published a brief account of his observations in a preliminary note addressed to the Bohemian Academy.[2] The two rudiments of what is subsequently to become the unpaired dorsal vessel of the adult *Criodrilus* are situated above, and rather to the side of, the intestine; their position in fact would appear to correspond very closely to the lateral vessels, or intestino-tegumentary trunks as Perrier has termed them, which are found in *Lumbricus* and in many other genera of earthworms, but do not seem to be repre-

[1] Mem. d. l'Acad. de St Petersb. 1871. [2] S. B. Böhm. Acad. 1879.

locustella) beside a small marsh about two miles from Arasaig, on the Fort William road.

20. *Sylvia trochilus* (Willow Warbler).—I observed one or two in a charming little woodland glen near Professor Macpherson's "Cottage," where their sweet songs and the sight of primroses and bluebell-hyacinths in profusion on the banks, irresistibly carried my thoughts from the lonely island to familiar scenes in our own immediate neighbourhood. The profusion of wildflowers, I may remark in passing, can hardly fail to attract the attention of a stranger landing on the island. The willow wren is also mentioned in Dalgleish's list.

21. *Regulus cristatus* (Golden-crested Wren).—This tiny bird is included in Joass' list. The Rev. Mr Macpherson states that he found a nest of the golden-crested wren on 21st May 1882, and that one was found by Mr Joass in 1881 (*vide Zoologist* for 1882, p. 420).

22. *Parus cœruleus* (Blue Tit).—Included in Joass' list. This is the only record I have of the blue tit having been observed in the island.

23. *Parus caudatus* (Long-tailed Tit).—Mr Joass' list is the sole authority I have for this species also.

24. *Motacilla Yarrellii* (Pied Wagtail).—Dr Stark mentions having seen pied wagtails, and remarks that they were "light in colour." Also included in Joass' list. There is a possibility that the birds Dr Stark saw may have been the continental form (*M. alba*) on migration.

25. *Motacilla boarula* (Grey Wagtail).—Observed by Mr Joass, and included in the list he gave Mr Dalgleish, under the name of "yellow" wagtail. I have communicated with Mr Joass on the subject, and he assures me the bird he saw was the grey wagtail, not Ray's.

26. *Anthus pratensis* (Meadow Pipit).—Seen in abundance, especially on the moorland parts of the island. Young ones (in nest) were seen by the Rev. Mr Macpherson on 22d May.

27. *Anthus obscurus* (Rock Pipit).—I observed a good many among rocks on the shore. Also mentioned in Stark's notes.

28. *Alauda arvensis* (Skylark).—Common, their sweet

carols sounding all the sweeter when heard amidst these island solitudes.

29. *Emberiza miliaria* (Corn Bunting).—Every little patch of crofter's corn or hay grass had its pair or more perched on the rude wall or other slightly elevated site, lazily repeating their monotonous notes. The corn bunting is one of the most abundant and familiar birds throughout the Hebrides, reaching even to the remotest islands. I remember Mr Harvie-Brown telling me when I was about to start in June 1882 for St Kilda (where we found it impossible, however, to set foot owing to the storm encountered), that when he landed there a year or two before, almost the first bird he noticed was the bunting, sitting beside the plots of corn, apparently quite at home.

30. *Emberiza schœniclus* (Reed Bunting).—Seen in two localities among tall heather and willows in boggy spots near the main road across the island. One pair had a brood newly out of the nest, and unable to fly.

31. *Emberiza citrinella* (Yellow Hammer).—Common. I found a nest containing two newly laid eggs; it was built among heather. Yellow yites never failed to make their appearance when the innkeeper's poultry were being fed.

32 *Fringilla cœlebs* (Chaffinch).—Not uncommon. Several, both old and young, made their appearance when the poultry were fed. A young bird, strong on the wing, was observed by the Rev. Mr Macpherson on 19th May 1882.

33. *Passer montanus* (Tree Sparrow).—On the 19th of June, I discovered a small colony[1] (about half a dozen pairs, as far as I could make out) of this interesting bird inhabiting holes in the ruins of St Donan's Chapel, or, as the islanders call it, Kildonan. I visited the colony two or three times, and climbed to one of the nesting holes, but did not ascertain what it contained. To have done so it would have been necessary to extract the nest—part of which was distinctly visible—piece-meal, a course I hesitated to adopt.

In the Society's *Proceedings* for Session 1881-82 there is an interesting and instructive paper by Mr Dalgleish on the distribution and habits of the Tree Sparrow, in which he

[1] Seen again, by the Rev. H. A. Macpherson, in June 1885.—Ed.

records the discovery, by himself, of a colony at Kilchoan, in the western end of Ardnamurchan, in August 1880. The first authentic record of its occurrence in the west of Scotland appears to be that in the Appendix to Gray's "Birds of the West of Scotland,"—the locality being near Ardrossan, and the date 1870; and at the time Mr Dalgleish read his paper (Feb. 1882), nobody would seem to have noticed it on the west coast, to the north of the Clyde, until he discovered it in Ardnamurchan as just mentioned. When I put these notes together, a week or two ago, it had not, so far as I could find, been recorded from any of the Western Isles; and I supposed I had been the first to trace it thither. A few days since, however, my attention was drawn to Mr C. Dixon's interesting paper, in the *Ibis* for the present month, on the Ornithology of St Kilda, where a pair were seen, and one of them shot, by that gentleman, on the 9th of June last. They breed, Mr Dixon states, in the holes of the rough stone walls that enclose the fields. This interesting discovery of the species in the outermost of the Outer Hebrides, thus preceded mine in the inner islands by ten days. The late Professor MacGillivray, writing in 1837 (*vide* "History of British Birds," vol. i., p. 350), remarks of the common house sparrow,—"it is singular that in the Outer Hebrides it was, until of late, to be seen only at Kilbar, in the island of Barray, where it had made its abode in a ruined church, although now, according to the minister of Stornoway, a few individuals have appeared in that town, where they will doubtless speedily multiply." May not these sparrows on the ruins of Kilbar church have been *Passer montanus*, a species which MacGillivray then confessed he had never to his knowledge seen alive? The prediction contained in the closing words of the above quotation has been abundantly fulfilled, as I can testify from personal observation. The house sparrow does not, however, appear to be a common bird, even in the inner islands, and though Mr Scott informed me he was sure he had seen it in Eigg,[1] I have, in the absence of positive evidence, thought it advisable to

[1] Mr Macpherson informs the Editor that he found a few pairs nesting in the cliffs in June 1885, close to a few pairs of the tree sparrow.

exclude it from the list. That a marked extension of range has been going on in this country of late years, in the case of the tree sparrow and several other birds, seems almost certain.

34. *Carduelis elegans* (Goldfinch).—Included in Dalgleish's list, on the authority of Mr Scott. In a letter to Mr Dalgleish, dated Eigg, 26th Jan. 1880, Mr Joass stated that he had seen it on the island several times.

35. *Linota montium* (Mountain Linnet or Twite).—I found this species in tolerable abundance all over the island, and anything but shy. They were constantly about the inn, and I saw them frequently on the hazel bushes,—which in many places abound on the slopes beneath the high basaltic crags that all but encircle the island,—as well as among the heather.

36. *Pyrrhula vulgaris* (Bullfinch).—Mr Scott informs me that he has over and over again, and up to the present time, seen this bird among willow and hazel bushes, in a particular glen near the centre of the island. Another person (a shepherd) told me he also had seen it there. I have submitted a coloured drawing of the Bullfinch to Mr Scott, and he quite recognises it. I ought to say that, before going to Eigg, Mr Scott resided in Perthshire, where this species is well known.

37. *Sturnus vulgaris* (Starling).—A few only were seen by me. Dr Stark, however, states that it swarmed about the cliffs on the Scuir at the time of his visit, April 1879. Mr Dalgleish also observed quite a number nesting in the rocks the same year. The breeding season of the species being over by the time of my visit, the birds had doubtless already congregated and gone elsewhere for a time.

38. *Corvus corax* (Raven).—Two broods were observed by me, one near the north and the other at the south end of the island. In 1879, when Mr Dalgleish visited the island, there were also just the two pairs; and the same number is mentioned by the Rev. Mr Macpherson in 1882.

39. *Corvus cornix* (Hooded or Grey Crow).—A well-known pest in Eigg, as elsewhere on the west coast. I did not observe many, however, and presume they are kept pretty well under.

40. *Corvus frugilegus* (Rook).—Mr Scott informs me that rooks visit the island during autumn and winter, but do not breed there.

41. *Troglodytes vulgaris* (Wren).—Common, the merry song ever and anon attracting attention to the sprightly little fellow perched on the top of a rock or a spray of heather, from which he pops down out of sight immediately the performance is over. I watched several of the birds carrying good sized caterpillars to their young ones among tall heather. The nest is here, as elsewhere, frequently placed in an outhouse, the same spot being tenanted year after year.

I may here mention that larvæ of the common currant moth (*Abraxas grossulariata*) were observed feeding on heather not far from the summit of the Scuir.

42. *Cuculus canorus* (Cuckoo).—Common. Its well-known call was among the first sounds I heard on landing.

43. *Hirundo rustica* (Swallow).—I did not see any, but was informed that a pair usually frequent the steading at the farm of Sandavore. Mr Scott has also seen them on the island.

44. *Cypselus apus* (Common Swift).—One was seen by Mr Dalgleish flying above the cliffs.

45. *Caprimulgus europœus* (Nightjar).—Included in Joass' list. They are abundant on the mainland, directly opposite Eigg. While staying at Arasaig I heard them every evening.

46. *Columba palumbus* (Ringdove or Wood Pigeon).—Mr Dalgleish notes that a pair were seen by Mr Scott in trees at the Cottage in 1879, and in a letter received from Mr Scott to-day he informs me there are a few there still.

47. *Columba livia* (Rock Dove).—Mr Dalgleish saw one or two near the famous cave. I saw only a single bird, and imagined the species might not be numerous on the island. Mr Scott, however, writes me that there are considerable numbers.

48. *Lagopus Scoticus* (Red Grouse).—Not abundant. I saw only a very few, but it is not the habit of grouse to show themselves much at that season of the year.

49. *Perdix cinerea* (Common Partridge).—Mr Scott writes

me that partridges were introduced about three years ago, but are not numerous yet.

50. *Charadrius pluvialis* (Golden Plover).—Included in Joass' list.

51. *Charadrius hiaticula* (Ringed Plover).—A few pairs were observed on the stretch of sandy beach near the landing place. Mentioned also by Mr Joass, who knew of two breeding places on the island. Three birds, "surprisingly fearless," were seen by the Rev. Mr Macpherson among rocks near the famous musical sands.

52. *Vanellus cristatus* (Lapwing).—In a letter to Mr Dalgleish, dated Eigg, 26th January 1880, Mr Joass says: "The lapwing, I think, breeds here, as I have noticed it at all seasons of the year." It is not mentioned in any of the other sources of information to which I have referred, and I did not observe it myself.

53. *Hæmatopus ostralegus* (Oystercatcher).—A few were observed in the bay near the landing-place. Included also in Mr Dalgleish's list; and observed on the shore at Laig by the Rev. Mr Macpherson. The oystercatcher is well known to be an abundant bird throughout the Hebrides generally. Numbers breed on the islands off Arasaig, where I found over a dozen nests in a few minutes. In 1882 I obtained three eggs from St Kilda.

54. *Ardea cinerea* (Common Heron).—Bred in Eigg in 1882, as recorded by the Rev. Mr Macpherson in the *Zoologist* for that year. He says: "Mr John Macpherson of Sandavore kindly offered to show me a heron's nest on a cliff at the north-west of Eigg. When I visited Eigg some ten or eleven years since, the herons from the mainland habitually patronised the Eigg fishing; but I believe that the species has not nested in Eigg, of recent years at any rate, until the present summer."

55. *Numenius arquata* (Curlew).—Several were seen feeding at low water in the bay near the landing-place. Also included in Joass' list.

56. *Totanus calidris* (Redshank).—Mentioned by Mr Scott, who appears to know the bird well.

57. *Totanus hypoleucos* (Common Sandpiper).—A few

observed on the shore near the Cave. Recorded, from the island, in Gray's "Birds of the West of Scotland." Seen also by Mr Dalgleish.

58. *Scolopax rusticola* (Woodcock).—Plentiful in hard winters. Mr Dalgleish was informed by Mr Scott, who has since repeated the statement to me, that he had killed as many as sixteen or seventeen in a day in the winter of 1878-79. Woodcocks breed in some numbers on the mainland between Fort William and Arasaig. Close to the latter place I came upon a pair, which, from the way they flew around, uttering all the while a curious cry resembling the syllables, *croak, croak, croak-oak-a-creek,* doubtless had a brood close by.

59. *Scolopax gallinago* (Common Snipe).—Two or three were seen by me. I had an excellent view of one which, in response to an imitation of its call, approached within three yards of where I was seated. Included also in Joass' list.

60. *Scolopax gallinula* (Jack Snipe).—My only authority for recording this species is Mr Joass, in whose list it is included.

61. *Crex pratensis* (Corncrake).—Very common. When sitting on the garden wall at the inn, I frequently saw one moving about among the short grass in the adjoining field. Each step was accompanied by a forward motion of the head, the familiar "creck, creck," being at same time uttered. A nest, which I found, was placed amid a patch of the yellow iris, and contained the remains of eight eggs newly sucked, evidently the work of a rat.

62. *Rallus aquaticus* (Water Rail).—Three were killed in the winter of 1878-79. This information was communicated to Mr Dalgleish by Mr Scott. Mr Joass mentions in his letter of 26th January 1880, previously referred to, that he frequently saw them that winter.

63. *Tadorna vulpanser* (Shelldrake).—Two or three were seen flying along the shore, opposite the Cave, having come from the direction of Castle Island, where, I understand, they breed.

64. *Anas boschas* (Wild Duck or Mallard).—I saw a pair

on a hill loch behind the Scuir, where they were doubtless breeding. The Rev. Mr Macpherson saw five or six on the Scuir lochs on 23d May 1882.

65. *Anas crecca* (Teal).—Mr Scott informed me that he had seen teal about the island. In Gray's "Birds of the West of Scotland" it is stated to breed in the neighbouring island of Rum.

66. *Somateria mollissima* (Eider Duck).—I learned from Mr Scott and others that a few pairs breed, or used to breed, on the Castle Island. Mr Joass informs me he has seen a brood of ducklings there. On the small islands out from Arasaig I put several females off their nests, and saw others with ducklings following them. The number of eggs in a nest or young in a brood in no instance exceeded three, but this was probably the result of frequent robbing of the nests.

67. *Mergus serrator* (Red-breasted Merganser).—Mr Scott informs me that three were shot recently, and sent to a professional bird-stuffer, by whom they were identified. I found the species common in the neighbourhood of Arasaig, and discovered a nest containing nine eggs; and I believe I saw a merganser flying close to the shores of Eigg.

68. *Podiceps*, sp.? (Grebe).—I found the remains of a grebe on the shore, but did not make out the species satisfactorily. It was evidently one of the middle-sized species, probably the Sclavonian grebe (*Podiceps cornutus*).

69. *Colymbus glacialis* (Great Northern Diver).—Not uncommon in winter. Mr Scott writes me that three were seen lately. I observed a single bird feeding in the channel between the landing-place and the Castle Island. On more than one occasion within the last year or two I have examined fresh specimens from Mull in the month of June.

70. *Uria troile* (Common Guillemot).—A good many were seen at sea as we approached the island.

71. *Uria grylle* (Black Guillemot).—I observed a fine male feeding in the channel between the landing-place and Castle Island, where I have no doubt the female was sitting on eggs or young. Mr Gray, in his "Birds of the West of Scotland," gives Eigg as a breeding-place. The same gentleman informs me that, when on a yachting cruise in the autumn of 1877,

he observed black guillemots off the shores of Eigg; and the Rev. Mr Macpherson states that he saw two on the Laig (west) side of the island in May 1882.

72. *Fratercula arctica* (Puffin).—A few were seen as we approached the island, but I could not discover that it breeds there, the bird known to the natives by the name of "puffin" being the Manx shearwater.

73. *Phalacrocorax carbo* (Common Cormorant).—This species is mentioned by Mr Gray in his "Birds of the West of Scotland" as breeding in Eigg. The "cormorant" is included in Joass' list, and the Rev. Mr Macpherson states that he counted six. It is just possible some of these observations may refer to the next species, which I think is allowed to be much the commoner of the two in the Hebrides.

74. *Phalacrocorax graculus* (Shag or Green Cormorant).—Two or three were seen and perfectly identified by me.

75. *Sula bassana* (Solan goose).—Seen by Mr Joass and included in his list. The following quotation from Dean Munro's account of his visit to the Hebrides between 1540 and 1549 is interesting as indicating that the species once nested in the cliffs of Eigg:—"North from Ellan Muchd be foure myles, lyes ane iyle called iyle of Egga, foure myle lange and twa myle braid, guid maine land with a Paroch Kirk in it and maney Solane geese." In John Monipennie's "Description of Scotland" (1612 edition, p. 240) it is stated that "In Egga are Solain Geese."

76. *Sterna macrura* (Arctic Tern).—A few terns were observed flying about the bay near the landing-place: a pair or two seemed to be breeding on some low skerries near the shore. With the aid of a strong field-glass I had a good view of some of them, and felt sure they were this species. The Rev. Mr Macpherson came to the same conclusion in 1882. He says: "On May 23d we felt fairly satisfied that a pair of noisy terns hovering about low were to be referred to *S. macrura*, though their lively movements made it difficult to scrutinise their beaks as minutely as I desired to do" (*vide Zoologist* for 1882, p. 420). Probably the common tern (*S. fluviatilis*) also frequents the fishing in the bay, as I satisfactorily identified both forms on the islands off Arasaig.

77. *Larus canus* (Common Gull).—A pair or two were seen about the grassy slopes of cliffs near the south-west corner of the island. They appeared to have young in the neighbourhood. I found the species breeding abundantly on some low flat islands near Arasaig.

78. *Larus fuscus* (Lesser Black-backed Gull).—A few were noticed about the shores of Eigg. There is a large colony on one of the islands near Arasaig.

79. *Larus argentatus* (Herring Gull).—Common. Breeds on precipitous rocks at the southern end of the island and elsewhere round the shores. Mr Gray informs me that when cruising off Eigg in August 1877, he observed, during a gale, great numbers of herring gulls. The main body sat on the rocks in the north end of the island; but, during the time the yacht took in passing, hundreds came seawards in the face of the storm, apparently with the greatest ease.

80. *Larus marinus* (Great Black-backed Gull).—Mr Dalgleish saw newly hatched young on an islet in a hill loch, attended by their parents. A pair of black-backed gulls were seen by me in the neighbourhood of the same loch, but they were very shy, and I did not pay much attention to the identification of them. The Rev. Mr Macpherson states that as he turned the corner of a cliff "suddenly up rose a large black-backed gull, who had been gorging on a dead lamb."

81. *Puffinus anglorum* (Manx Shearwater).—This is *par excellence* the bird of Eigg; so much so, indeed, that its Gaelic name, "Fachach," is applied to the Eigg fishermen by their neighbours in the surrounding islands. Old and young birds alike are known by the name Fachach, but none of the natives of whom I made inquiries knew it by the name of shearwater. Those who had an English name for the bird called it the puffin, a name by which it would appear to have been long known in the Hebrides. Thus, M. Martin, in his description of the Western Isles published in 1716, speaking of Rum, says, "There is plenty of land and sea fowl; some of the latter, especially the puffin, build in the hills as much as in the rocks on the coast,"—the reference, I think, being clearly to the shearwater, which, I understand, still breeds

in Rum at a considerable elevation. Coming down to 1859 we find the following interesting passage in Hugh Miller's "Cruise of the Betsey" (p. 89), the latter part of which substantially agrees with what the Eigg folks gravely assert to this day: "The puffin, a comparatively rare bird in the Inner Hebrides, builds, as I was told, in great numbers in the continuous line of precipice which, after sweeping for a full mile round the bay of Laig, forms the pinnacled rampart here, and then, turning another angle of the island, runs on parallel to the coast for about six miles more. In former times the puffin furnished the islanders, as in St Kilda, with a staple article of food, in those hungry months of summer in which the stores of the old crop had begun to fail, and the new crop had not yet ripened; and the people of Eigg, taught by their necessities, were bold cragsmen. But men do not peril life and limb for the mere sake of a meal, save when they cannot help it; and the introduction of the potato has done much to put out the practice of climbing for the bird, except among a few young lads who find excitement enough in the work to pursue it for its own sake as an amusement. I found among the islanders what was said to be a piece of the natural history of the puffin, sufficiently apocryphal to remind one of the famous passage in the history of the barnacle, which traced the lineage of the bird to one of the pedunculated cirripedes, and the lineage of the cirripede to a log of wood. The puffin feeds its young, say the islanders, on an oily scum of the sea, which renders it such an unwieldy mass of fat, that about the time when it should be beginning to fly, it becomes unable to get out of its hole. The parent bird, not in the least puzzled, however, treats the case medicinally, and—like mothers of another two-legged genus, who, when their daughters get over stout, put them through a course of reducing acids to bring them down—feeds it on sorrel leaves for several days together, till, like a boxer under training, it gets thinned to a proper weight, and becomes able, not only to get out of its cell, but also to employ its wings."

The islanders have not yet altogether lost their relish for the "Fachach," and still enjoy a dish of it when it can be

got; but there do not appear to be many folks in the island now who care to undertake the risk which climbing for it on an extensive scale involves. One lad, however, informed me that he and a companion had taken as many as forty a-piece in one day in 1883. The young birds, which at one stage of their existence are remarkably fat, are principally sought for; but the old ones too are taken when found in the burrows.

The numbers which annually repair to the cliffs of Eigg to rear their young must be very considerable indeed. Some time before we reached the island, dozen after dozen passed our boat, flying seaward in rapid succession to a rendezvous on the heaving waters, where they settled, forming a dense flock, which, as it rose and fell, looked in the distance not unlike a mass of great floating seaweed. The flock must have consisted of many hundreds of birds. A similar gathering, estimated at seven or eight hundred, many of them birds of the year, were observed by Mr Gray riding on the waves in the neighbourhood of Eigg in August 1877, as recorded in the Society's *Proceedings* for Session 1877-78 (vol. iv., p. 213).

The shearwaters breed principally, if not entirely, in burrows, wherever sufficient soil is found, high up in the precipitous crags which rise above the talus at a greater or less distance from the shore, the rampart of black basalt surrounding the bay of Laig being as formerly a favourite resort. The spots likely to contain burrows are readily detected, even at a distance, by the presence of an abundant vegetation, but owing to the rotten nature of the rock composing the cliffs to be ascended, or descended, as the case may be, before these green spots can be reached, and the labour of digging out the nests, the eggs are by no means easy to obtain. According to Saxby ("The Birds of Shetland," p. 365) the burrows are dug by the birds themselves, and vary "from eighteen inches to two feet in depth, or even more, and are so narrow that the introduction of the hand is a matter of some difficulty when the hole happens to be new, and therefore but little worn by the passage of the bird." All the burrows I examined, however, were from four to five or

more feet in length, and wide enough to admit the arm with ease, and had all the appearance of having been excavated by rabbits, of which I saw a number. The soil not being deep, the burrows never penetrated, in any part of their course, far from the surface; and though the ground was very hard, owing to a more than usual amount of dry weather, I managed with the aid of my fingers and a stout walking-stick to dig up about a dozen nests, and found four eggs (the bird lays but one), two fresh and two highly incubated. All the other burrows contained very young birds, covered with a delightfully soft lightish slate-coloured down. A few twigs of heather and withered blades of grass were all I could find in the way of lining to the nests. One of the parent birds, sometimes the female and sometimes the male, was in each burrow.

The adults used their bills freely when caught and handled, but I never heard them utter any sound; though the young ones, when brought into the light of day, indicated their dislike to it by a feeble cheep. I never saw the birds coming to or leaving their nests: this they appear to do entirely under cover of night, or in the dusk of the evening and morning; and I was sorry that a heavy fall of rain on the evening I had arranged to spend in their haunts prevented me verifying this part of their habits. The old man, who, on the occasion of my first visit to the colony, acted as guide, and directed my steps among the cliffs, insisted that it was needless to let the birds off in the daytime, as they would certainly be at once attacked by gulls or other enemies, and brought to an untimely end. Suspecting, however, that his fondness for them in a cooked state had prevented him from ever trying the experiment, I drew one out of its burrow and threw it into the air, when it instantly spread its wings and sped seawards without hindrance of any kind. From the mouths of a pair, which the guide reserved for the pot, a beautiful green fluid exuded.

82. *Puffinus major* (Great Shearwater).—Mr Gray in his note in the Society's *Proceedings* for 1877-78, already referred to, states that "one or two larger and much darker birds were observed in the flock" (of *P. anglorum*), which he "took

to be the greater shearwater (*P. major*)."[1] The fact that they were so dark in colour would, however, appear rather to point to another species, the sooty shearwater (*P. griseus*), long mistaken for the young of *P. major*.

83. *Thalassidroma Leachii* (Fork-tailed Petrel).—Mr Gray, in his "Birds of the West of Scotland," mentions Eigg as one of the islands from which he had obtained specimens of this Petrel.

84. *Thalassidroma pelagica* (Storm Petrel).—In the same work it is stated that a colony of this species has long existed on Eigg. The author informs me that he obtained most of of his Eigg records from the late Dr Dewar of Glasgow.

XXXVI. *Note on the Breeding of the Marsh Tit* (Parus palustris) *in Stirlingshire during* 1884. By William Evans, Esq., F.R.S.E. [Nest and Eggs exhibited.]

(Read 17th December 1884.)

The nest of the Marsh Tit, which forms the subject of this note, was taken at Dunipace, near Larbert, the residence of Mr J. A. Harvie-Brown, on the 24th of May last. Although the actual finding of this nest fell to my lot, the credit of the discovery really belongs to Mr Harvie-Brown, who has for a number of years been aware of the presence of the species on his property, as well as in other parts of Stirlingshire, during both spring and autumn,—more especially the latter; and a pair having been observed haunting a small wooded glen near the mansion-house rather later than usual last spring, a search for the nest was instituted, with the result that, on the 8th of May, a partially formed nesting-hole was discovered in one of the half-decayed paling stobs or stakes with which the old thorn hedge, that skirts the glen and separates it from the adjoining field, is studded. As Mr Harvie-Brown was under the necessity of leaving home for a few weeks, he was unable personally to follow up his dis-

[1] The Rev. H. A. Macpherson informs the Editor that he obtained a specimen of the Greater Shearwater on the coast of Skye in July 1885.

covery, and was good enough to leave the matter in my hands. Having allowed the birds sufficient time for the completion of their task, I visited the spot on the 24th of May, but was disappointed to find that, from some cause or other, they had abandoned the nest at which they had been found working on the 8th of the month. As they were not likely to have removed to any great distance, I proceeded to examine all the suitable stobs along the hedge, and had not gone far when I had the pleasure of seeing a Marsh Tit scramble out of a small hole in the side of one of these stakes. I watched the bird enter and leave the nest several times; and, for the sake of complete identification, afterwards caught it, setting it, however, immediately at liberty again. The male bird was rather shy, but his loud *tzay, tzay, tzay,* was heard continually sounding through the wood. Having thus put the question of identity beyond all doubt, I carried off the stake, the greater part of which you have now before you.

There are one or two points about this post or stake to which you will perhaps permit me to draw attention. It has been formed, you will observe, by splitting a section of a spruce of about 6 inches diameter, into four. A cross section would thus be broadly wedge-shaped,—in fact, the quarter of a circle,—the sides containing the point of the wedge measuring about 3 inches, and the rounded or outside part about 4½ inches. The utmost inscribed circle which such a section would contain, would have a diameter of about 2¼ inches; and, if we make allowance for the walls of the chamber, it will be seen how very limited was the space in which the tiny excavators had to work. The hole has been penetrated entirely by their own labour. The rounded part of the stob, which must of course have formed part of the exterior of the tree, and has still some of the bark adhering to it, is comparatively soft and easy to penetrate. The other sides, however, are much firmer, but within these walls the wood is quite decayed and soft. The rounded side being the softest, is naturally that in which the entrance has been made. Laterally, the entrance, which has unfortunately been slightly damaged, is scarcely an inch wide, and the depth

of the hole is about 9 inches. The lining, or nest proper, is composed principally of rabbit fur, mixed with scales of the leaf buds of trees,—mostly beech,—and other soft materials. The inside measurement of the bottom of the nest is little if anything more than an inch and a quarter across. In it lay five all but fresh eggs of the usual titmouse type. They have, however, to my eye a higher gloss than those of the other British species. From the eagerness of the bird to return to the nest each time it was disturbed, it seems probable the complement of eggs was complete or very nearly so. I should have pointed out that immediately below the hole containing the nest, there is a second chamber, which had most probably been abandoned in consequence of the occurrence of a knot or other obstruction in the wood, and operations recommenced higher up the stake.

Though comparatively common in many parts of England, the Marsh Tit appears to be a decidedly rare and local species in the basin of the Forth, and indeed in Scotland generally. Although convinced I have previously heard its call-note in our district, it was not till my visit to Dunipace last May, that I actually saw the bird,—not, however, for the first time in my experience, as I had already become acquainted with it, to a certain extent, both in Norway and in Switzerland. Since taking the nest at Dunipace, I have been fortunate enough to see the bird in our own county, Midlothian. This was on 30th August last, when I had an excellent view of a pair travelling in company with Blue and Greater Tits, about two miles south of Midcalder station. While watching this pair, I observed them alight several times on the flowers of the Common Ragwort, a habit which had not escaped the keen observation of the late Prof. MacGillivray, who remarked that he had seen this tit alight on herbaceous plants, especially thistles. No doubt these visits to the flower-heads of the *Compositæ* are made in search of the insects, to which they prove so attractive. Mr Harvie-Brown feels sure the species has recently bred near Kippen, in Stirlingshire, and asserts that it is much more common in that county in autumn than it used to be. In MacGillivray's day it was considered rare in Scotland, and

he gives[1] full particulars of two nests, discovered by his friend, Mr Weir, in the trunks of decayed Scots firs in a plantation near Bathgate, in July 1838. The first was found on the 22d of the month, and contained five young birds; the second was found on the 28th, and contained five eggs. These were the only nests Mr Weir had known in the long period of 14 years. Since then the species has been reported to breed in several parts of Scotland,—and doubtless has done so frequently,—but I do not think that a really undoubted nest has been recorded, from the valley of the Forth at any rate, since the two found by Mr Weir in 1838, till now.

XXXVII. *Note on the Contents of Two Bits of Clay from the Elephant Bed at Kilmaurs in* 1817. By JAMES BENNIE, Esq., H.M. Geological Survey of Scotland.

(Read 20th May 1885.)

The two bits of clay, the subject of this note, came to Edinburgh along with half of the elephant tusk of 1817. They were sent by Mr Alex. Hood, Surgeon in Kilmarnock, and a note regarding them was read by the secretary, Mr Patrick Neill, which was said[2] to give a "more particular description of the fossil tusks than a notice read at the meeting of June 7th of the same year."[3] It is added that Mr Hood presented the part of the tusk he sent in to the Society. That "more particular description" seems not to have been published or even preserved, nor does any further notice of this discovery occur till 1822, when Mr Bald, after describing his discovery of the tusk of an elephant at Clifton Hall, referred to the previous discovery at Kilmaurs, and gives the following particulars: "The only other instance I know of elephants being found in the alluvial cover in Scotland was in the parish of Kilmaurs, Ayrshire, near the Carmel Water, in a property belonging to Lord Eglinton. They were dis-

[1] Hist. Brit. Birds, ii., p. 448.
[2] Wern. Mem., ii., p. 525.
[3] See Wern. Mem., ii., p. 662, June 7, 1817.

covered in the beginning of January 1817 by Mr Robert Brown, tacksman of the sandstone quarry of Greenhill, while removing the earth from the rock. At the depth of 17½ feet from the surface he discovered two tusks, one of which measured 3 feet 5½ inches in length and about 13½ inches in circumference. The other was similar, but so much decayed, that it could not be preserved. . . . The tusks were found lying in a horizontal position, with several small bones near them, and it is particularly to be remarked that several marine shells were found amongst the dark coloured earth. The tusk," Mr Bald continues, "weighed 20½ lbs. English weight, and was sent to the Earl of Eglinton. It was afterwards cut through across, and one part of it is to be seen in the saloon at Eglinton Castle, the other was sent to the College Museum at Edinburgh. The exterior is of a brown colour and very hard, but the greater part of the interior is much decomposed, has lost the ivory texture, and though not absolutely soft, is similar in appearance to half rotten wood."[1]

Other tusks were subsequently found in the same quarry—one which is in the Museum of Anderson's College, Glasgow, and two which are in the Hunterian Museum of the University of Glasgow—in all, nine tusks have been found at Kilmaurs, representing, as Dr Scouler humorously remarked to Mr Geikie, "at least four and a half elephants."

The detailed notices of all the "finds" may be found in the paper by Mr Bald in vol. iv. of the *Memoirs of the Wernerian Society;* in the "Glacial Drift of Scotland," by Professor Archibald Geikie, in the first volume of the *Transactions of the Geological Society of Glasgow;* in the paper by Dr Bryce in vol. xxi. of the *Quarterly Journal of the Geological Society;* and in an elaborate paper by Mr John Young of the Hunterian Museum, Glasgow, and Mr Robert Craig of Langside, Beith, in the *Transactions of the Geological Society of Glasgow,* vol. iii., p. 310. From these various papers we learn that the tusks were found in a bed of clay and sand, which was overlaid by a superincumbent mass of boulder

[1] Wern. Mem., iv., p. 68.

clay, varying in thickness from 17 feet in 1817 to 36 feet, as proved by Dr Bryce in 1866. The difference in thickness was due to the quarry having been commenced in the slope of a boulder clay hillock, where the clay was shallowest, but which increased in thickness as the quarry was carried forward. The bed of clay and sand in which the tusks lay rested on a "bed of gravel and rolled stones," as recorded in the *Ayr Observer* newspaper of 23d January 1817.

Having given in these prefatory remarks some of the dates and circumstances of the discovery of the elephant remains at Kilmaurs, I come now to the incidents upon which this note is founded. In the year 1878, the Council of the Royal Society of Edinburgh, finding themselves hampered for room to store their books, resolved to clear the museum attached to the library of a large number of specimens, and give them to the University of Edinburgh for the use of the Professor of Geology, who at that date was Professor Archibald Geikie. In looking over them, a portion of an elephant's tusk was found with a label pasted on it, which proved it to be the half of the tusk of 1817 referred to in the minutes of the Wernerian Society of 20th December 1817. Along with the tusk was a small paper parcel, in which were several specimens of stones and clay and two fragments of bones, and a piece of paper, on which was written that they were referred to in the note accompanying the tusk. Professor Geikie took the tusk and placed it in his class museum, where it has remained ever since, being used in illustrating his lectures. While examining the paper parcel, I, remembering that Mr John Young had washed a bit of clay which had been sent with the tusk which had been placed in the Hunterian Museum, and found in it numerous seeds of water plants, suggested, that the two bits of clay might be washed with a like result. This suggestion was not acted upon, and the specimens were parcelled up again and put aside in the storeroom of the Geological Survey. About two years ago, while searching for other things, I came accidentally upon the parcel, and having time then, thought I might try to wash a small crumb of one of the bits of clay. The result was satisfactory, and I washed the greater part of that

bit and the whole of the other. The first bit I washed was about 4 inches square and less than 1 inch in thickness. The contents were one valve of *Astrarte compressa*, a few valves of *Leda pygmæa*, and a goodly number of Foraminifera and Ostracoda. These I mounted on slides, and sent the Foraminifera to Mr Henry B. Brady, who at once very kindly named them, and the Ostracoda to Mr David Robertson, who as kindly named them, and to both my warmest thanks are due for the trouble they have taken with them.

List of Foraminifera, determined by H. B. Brady, Esq., F.R.S., December 1883.

Miliolina seminulum, Linn.
Glandulina lævigata, D'Orb.
Polymorphina lactea, W. and J.
Cassidulina crassa, D'Orb.
Truncatulina lobatula, Walker.
Rotalia Beccarii, Linn.
Polystomella striato-punctata, F. and M.
Nonionina scapha, F. and M.
,, *orbicularis*, Brady.

In all nine species. Of their character Mr Brady says: "They are a *starved* lot from shallow water depth, certainly not more than 100 fathoms—probably not more than 50 fathoms—all more or less arctic."

List of Ostracoda, determined by David Robertson, Esq., F.L.S., January 1884.

Cytheridea sorbyana, Jones.
,, *papillosa*, Bosq. (Young).
,, *punctillata*, Brady.
Cytheropteron latissimum, Norman.
Cythere dunelmensis, Norman.
Cythere viridis, Müller.
,, *mirabilis*, Brady.
,, *concinna*, Jones.
,, *limicola*, Norman.
Eucythere argus, Sars.

In all ten species of Ostracoda. As to their character, Mr Robertson says: "They are generally of a decided arctic character, and much like those got in the deposits at Elie, Errol, and Barrie. It is clear from the contents that this bit of clay was of marine origin and much of the same character as the glacial clays of Paisley and Glasgow."

The other bit of clay was red in colour and much coarser in grain. On being placed in water it dissolved readily, and released its contents, which, being mostly seeds, immediately floated, and were secured without difficulty. These Mr Robert Kidston very kindly undertook to get named for me, and has

submitted them to Mr Bennett of Croydon, who has made a special study of the Potamogetons. Mr Bennett reports one kind to be a Potamogeton, whose affinity is doubtless with *P. rufescens*, Schrad; another Potamogeton, whose affinity is with *P. Zizii* and *P. heterophyllus;* and also several seeds of *Chara.*

The other seeds, comprising three or four different kinds, have not yet been fully determined. Mr Kidston says "that some of them certainly are those of the water *Ranunculus*, and others may be the fruit of *Carex* and *Polygonum.* There were also many fragments of the dried stems of thread-like plants whose character could not be made out. Nearly the whole body of a very small beetle and two fragments of another turned up in the seedy clay. Several other organisms, small, cylindrical, and cocoon-like, also occurred."

Such are the contents of these two bits of clay so far as yet determined. One speaks of the sea and the other of the land, and both of a time when the cattle of Ayrshire were the reindeer and the mammoth, and the valley of the Carmel Water was the haunt of the walrus and the whale—larger mammals, no doubt, but not to be preferred either in beauty or utility to the small variegated kye which are now the pride and glory of Ayrshire.[1]

The Position and Age of the Elephant Bed at Kilmaurs.

This is rather a vexed question, and I refer to it principally to correct one or two erroneous statements regarding it. Mr Bald, whose record was written in 1821, only four years after the finding of the first tusk, and which is the best

[1] The specimens referred to in the notice read at the Wernerian Society, Dec. 20, 1817, were exhibited to the Royal Physical Society when this note was read. They consisted of (1.) portion of the leg bone of probably a deer; (2.) fragment of bone; (3.) remainder of marine clay not washed; (4.) seedy clay, as it was all washed only the seeds were exhibited; (5.) clay, probably boulder-clay; (6.) portion of cast in sandstone of a carboniferous plant; (7.) two fragments of limestone with striated surfaces; (8.) piece of sandstone, probably the rock quarried; also two fragments of coal and one piece of pyritous sandstone. The original numbers were still on the specimens except No. 4. The fragments of coal and pyritous sandstone seem never to have been numbered.

account yet given of the tusk of 1817, was of opinion that it was not found like the tusk of Clifton Hall in the boulder-clay, which he designated the old alluvial cover, but in the recent alluvial cover, which he considered proved by the marine shells found with it. Dr Scouler, who furnished the particulars regarding the Kilmaurs elephants, published by Mr Smith of Jordanhill in the "Wernerian Memoirs" in 1838, judging from what he found himself—"a molar tooth on the clay heaps"—concluded that the remains were really in the boulder-clay. Dr Bryce, however, in 1866, by opening the quarry again of set purpose, found that the elephant remains were actually got in beds under 16 feet of real boulder-clay and 20 feet of what he called upper drifts, and of course concluded that their age and position was pre-glacial. The same opinion was adopted by Messrs Young and Craig in their elaborate "Notes on the occurrence of beds of fresh-water plants and arctic shells, along with the remains of the mammoth and reindeer in beds under the boulder-clay,"[1] in which in great detail is given their discovery of the peat bed and arctic shell bed in numerous pit sections in and around Kilmaurs, with lists of the seeds and shells found in them. From the evidence gained by their discoveries, beyond what was formerly known, they concluded "that it tended to establish in a clear manner the existence of two sets of strata of different origin and age under the boulder-clay of the Carmel valley at Kilmaurs—the lower being of fresh-water origin; the upper an arctic marine deposit;" and add, without giving a decided expression as to the particular age of either deposit, "we are, however, inclined to view them as pre-glacial remnants of the oldest post-tertiary beds yet discovered in the west of Scotland, and from the character of the organisms, marking, as it were, the dawn of the glacial period in this country."

In the explanation to sheet 22 of the Geological Map of Scotland, published in 1871, an opinion is given that the elephant bed at Kilmaurs was interglacial in position and age. This opinion is there said to be founded on "an exami-

[1] Trans. Geol. Soc. of Glasgow, iii., p. 310.

nation of the numerous bores and pit sections which have been made in the course of mining operations in the Kilmaurs district, which showed that the boulder-clay there contains interstratified beds of sand, gravel, and clay. Where the level of the surface of the solid rocks rises towards the surface of the ground the intercalated strata of sand die off against the slope until the rocks come to be covered directly by the overlying boulder-clay. Where, on the other hand, the level of the rocks sinks, as it does southward and westward, it passes beneath the horizon of the sand beds, and a lower boulder-clay makes its appearance under these beds. There cannot be any doubt that the strata containing the organic remains were formed during the deposition of the boulder-clay which lies beneath and above them, and that the cause of their sometimes being found to rest on the solid rock without a lower mass of boulder-clay is due to the irregularity of the surface on which the whole of these drift deposits were laid down.

"The peaty matter and the bones of the mammoth and rein-deer found at Kilmaurs are thus," it is concluded, "strictly parallel to those found in similar condition at Airdrie. They probably indicate the passing of what have been called interglacial warm periods or seasons, when the covering of ice upon the country had retired sufficiently to permit an arctic vegetation to spring up on the land and some of the larger northern mammals to roam over it."

Messrs Craig and Young exhibited at the meeting of the Geological Society of Glasgow on 12th January 1882 a portion of a tusk of the mammoth and a number of arctic shells recently obtained by them from the sinking of a pit near Dreghorn, nearly 3 miles from Kilmaurs. These remains are stated to have been found on a series of muddy sand beds resting directly on the carboniferous strata, at a depth of nearly 90 feet from the surface, and underlying the lower boulder-clay of the district, and in reference to the statement just quoted from the explanation to sheet 22 they say "that that fact—namely, that the beds containing the arctic shells and the elephant remains rested directly on the carboniferous strata at Dreghorn—proved that the statement requires cor-

rection, for that there was no evidence whatever for it, but rather directly against it," and they reiterate their opinion that these deposits are of preglacial age.

But from a paper which appeared in the *Irvine Herald* newspaper of date 4th October 1884, and evidently written by Mr Craig, it appears that the statement that the elephant beds rested directly on the carboniferous strata was founded upon some misconception or mistake, for it is there distinctly stated that below the shell bed in which the tusk of 1882 at Dreghorn was found there "lies 20 feet of sand and gravel resting upon the carboniferous strata; and further, in trying to fix the age of the beds," Mr Craig says "that the physical evidence is against the use of the term 'preglacial,' because that in the large accumulation of the sand and gravel beds that lie between the carboniferous strata and the shell and mammoth beds, *boulders of West Highland rocks are abundant.*" These are, he continues, "granites, schists, clay slates, and other rocks such as are found in the boulder-clay that rests upon the mammoth and shell beds." "These boulders," he further continues, "are not of large size, and are apparently beach-worn; still they could only be brought into their present condition either through the agency of drift or land ice." "These erratics," he further states, "are found from the bottom to the top of the sand beds, and whatever method of transport be adopted, the long period that must have elapsed during the accumulation of the boulders by whatever means is not favourable to the preglacial formation of these fossiliferous beds." "The term interglacial," Mr Craig continues, "is scarcely less objectionable. There is no satisfactory evidence that any of these sand and gravel beds are the production of land ice. There has indeed been found in a few bores wide apart, and not always on the same horizon, a clay or sand mixed with gravel. This might have been brought by the same agent that carried the boulders—drift ice. The regular division of the deposit into beds, and, as far as pits have shown, into beds that are laminated, is not favourable to deposition by land ice, but on the contrary, in favour of a water origin—still the term (interglacial) is more preferable to the mammoth beds at least than preglacial, seeing that the underlying beds have a glacial relation."

In conclusion, I think the suggestion may be hazarded that this 20 feet of sand and gravel, full from bottom to top of West Highland blocks, which Mr Craig clearly states lies between the carboniferous strata and the mammoth beds, shows that the statement in the explanation to sheet 22 requires not correction but expansion—and that if in addition to the warm interglacial season it predicates to account for the retirement of ice from the land to permit an arctic vegetation to grow on it, and some of the larger northern mammals to roam over it, we must also suppose a partial submergence, during which the lower boulder-clay in certain places was by water reassorted into sand, gravel, and mud, and redeposited with its boulders water-worn, as the laminated beds so graphically described by Mr Craig.

XXXVIII. *Observations on Living Cephalopoda.* By William E. Hoyle, Esq., M.A. (Oxon.), M.R.C.S., F.R.S.E.

(Read 20th May 1885.)

Abstract.

The author gave a very brief outline of the organisation of *Octopus* and *Loligo,* and some account of their general behaviour and movements as observed in the aquarium at Naples.

Some details respecting the action of the suckers in *Octopus,* and the motion of the fins in *Loligo,* were also added.

XXXIX. *Note on* Loligo Forbesii, *Steenstrup, the so-called* L. vulgaris *of our coasts.* By William E. Hoyle, Esq., M.A. (Oxon.), M.R.C.S., F.R.S.E.

(Read 20th May 1885.)

I venture to bring this communication before the Society this evening, not on the ground of novelty, but because the

subject in question is of importance to naturalists in this district, and because the publication of this note may lead to the correction of a mistaken piece of nomenclature which appears in many of our museums.

So long ago as 1857 Professor Steenstrup recognised the distinctions between the common species of the North Sea and that of the Mediterranean, and pointed them out in his classic treatise on the Hectocotylus formation,[1] from which I quote the passage referring to this matter:—

"The specific distinctions between *Loligo vulgaris*, Lamk., and *Loligo Forbesii*, Stp., are best derived from the form and size of the suckers on the tentacles: in *L. vulgaris* of the Mediterranean, as described and figured by D'Orbigny and Verany, and also in a form of our coasts which may certainly be regarded as *L. vulgaris*, these are very large in the two central rows and very small in the lateral rows, so that a transverse section of the latter is only half that of the former, and their height only one-third; whilst in *L. Forbesii*, Stp., the suckers of the central rows scarcely exceed those of the lateral rows, either in transverse section or in height; and, on the whole, it appears as if the club of the tentacle had four series of suckers of equal size. In comparison with the suckers of the arms, the disks of the central rows of the tentacles in *Loligo vulgaris* are from two to three times as large as the largest disks on the third arm, whilst in *L. Forbesii* they are scarcely one-third larger. The horny ring in the central rows of suckers in *L. vulgaris* has only one-half of its circumference finely toothed, whilst the other half is toothless, or only bears a group of 4-5 small blunt teeth (in a northern form these are indeed the only teeth on the horny ring): in *L. Forbesii* the ring bears numerous pointed teeth all round, and these are usually larger and smaller alternately. In this species, also, the suckers of the lateral series have the horny ring completely set with teeth of equal size, whilst in *L. vulgaris* their horny ring has high-pointed teeth in the upper half, and the lower half almost toothless. In colour, also, *L. Forbesii* is characterised by having the colour-sacs united into linear spots on the anterior part of the sides and also down the ventral surface. These long, dark markings, and the nearly uniform size of the tentacular suckers, consequently distinguish this species from *L. vulgaris* at the first glance."

The species thus recognised and defined by Professor Steenstrup is very common on our coast, and is continually brought in in large numbers by the Newhaven trawlers, and

[1] *K. dansk. Vidensk. Selsk. Skrifter*, Række 5, Bd. iv., p. 189, 1856. I quote from Mr Dallas' translation, *Ann. Mag. Nat. Hist.*, ser. 2, vol. xx., p. 84, 1857.

sold to the line fishermen for bait. It is, I am told, no uncommon thing for two or three hundred to be captured at once. The autumn appears to be the season of the greatest abundance, but seeing that the spawn is very commonly taken in the spring also, it can hardly be that they approach our shores at that period for the purpose of depositing it.

The males are more common than the females,—indeed, at the time of writing the paper above quoted, Professor Steenstrup had not seen the latter. Of nine specimens in my possession, seven are males and two females.

Whether the true *Loligo vulgaris* occurs on the British coast, I cannot say from my own observation; and owing to the confusion which exists in the nomenclature of the subject, it is impossible to ascertain from the descriptions of others.

In conclusion, I append a synonymy of the species and a tabular statement of its differences from the typical *L. vulgaris.*

Loligo Forbesii, Steenstrup.

1758. *Loligo* ——, Borlase (?), Nat. Hist. Cornwall, p. 260, pl. xxv., fig. xxvii., Oxford.[1]
1853. " *vulgaris,* Forbes and Hanley, Brit. Moll., vol. iv., p. 226, vol. i., pl. LLL.
1854. " sp., Stp., Foredrag om Sömunken.
1856. " *Forbesii,* Stp., K. dansk. Vid. Selsk. Skr., Rk. 5, Bd. iv., p. 189.
1858. " *magna,* Adams, H. and A., Gen. Rec. Moll., pl. iv., fig. 3.
1860. " *Forbesii,* Malm, Nya fiskar, etc., Götheborg Handl., viii., p. 132.
1869. " " Fischer, Journ. Conch., sér. 3, t. ix., pp. 128-130.
1869. " *vulgaris,* Jeffreys, Brit. Conch., vol. v., p. 130, pl. v., fig. 2.
1869. " *Forbesii,* Targioni-Tozzetti, Comment. Cefalop. Medit., Bull. malacol. ital., ann. ii., pp. 33, 35 (sep. copy).
1872. " " Fischer, Journ. Conch., sér. 3, t. xii., p. 23.
1879. " " Tryon, Man. Conch., vol. i., p. 147.

Habitat.—Firth of Forth; North Sea and coasts of Great Britain; Oceanic coasts of France; Scandinavia.

[1] Gray (Brit. Mus. Cat., p. 70, 1849) gives this reference as *Loligo Biscale,* p. 226, but indicating the same figure; I give it as I found it in the copy in the Advocates' Library, Edinburgh.

Loligo vulgaris, Lamk.	*Loligo Forbesii*, Stp.
Two large and two small rows of suckers on the tentacles, the former twice as broad and three times as high as the latter.	Four sub-equal rows of suckers on the tentacles.
Largest tentacular suckers two to three times as large as those of third sessile arm.	Largest tentacular suckers scarcely one-third to one-half larger than largest on third sessile arm.
Horny ring of central row of suckers finely toothed only in distal half, or bears only a group of four or five small blunt teeth.[1]	Horny ring of central row of suckers finely toothed all round, teeth large and small alternately.
Suckers of lateral series have high pointed teeth in the distal half, and are elsewhere toothless, or with very small teeth.	Suckers of lateral series completely set with teeth of sub-equal size, though somewhat smaller on the proximal half.
Chromatophores distributed evenly and not collected into bands.	Chromatophores united into broad bands of colour down either side.

XL. *Caseous Tumours found in the Muscles of the Hake.* By G. Sims Woodhead, Esq., M.D., F.R.C.P.Ed. [Plate XXIII.]

(Read 18th March 1885.)

Dr Ramsay Traquair has placed in my hands portions of the muscle of a large hake which have been forwarded to him from the North of Scotland. The following is a note of the appearances presented on naked eye and microscopic examination.

The specimens consist of small masses of the dorsal and lateral muscles of a large hake. They are preserved in methylated spirit, and for the most part are perfectly bleached. On examining more carefully, it is found that in the centre of the largest piece of muscle there is a

[1] On the basis of these differences *L. vulgaris* has been divided by Professor Targioni-Tozzetti ("Comment. Cefalop. Medit."—*Bull. malacol. ital.*, anno ii., pp. 35, 36, 1869) into two species,—one found in the North Sea, for which he retains the original name, and the other found in the Mediterranean, which he terms *L. mediterranea.* The material in my hands is not sufficient to enable me to form an opinion as to the necessity for this step: Dr Paul Fischer has not approved it (*Journ. Conch.*, ser. 3, t. xii., p. 21, 1872).

dark mass, which, shining through the pale muscle, renders one point considerably darker than the surrounding tissue. On section through the middle of this dark point, a cavity half-an-inch in diameter is found. This is bounded by a narrow zone of fibrous-looking tissue, which forms the wall of the cavity, and intervenes between it and the surrounding muscular tissue. This zone is translucent and grey, without a tinge of the yellow observed in the muscles. Within the cavity and attached, apparently only at a single point, is a firm nodular mass of about the consistency of beeswax. It is much browner than the surrounding tissues, and running through it are deep brown streaks, almost like old blood pigment stains. There is no fibrillation of the mass, which breaks down irregularly, and has no definite line of fracture. In some of the smaller pieces of muscle, similar cavities and nodules are seen; they are much smaller; the nodules are not so deeply stained, are attached almost continuously to the walls of the cavity, and are not quite so brittle.

On making a microscopic examination of the tissue which lies outside the fibrous-looking lining of the cavity, the following appearances may be distinguished. The striped muscular fibres first attract one's attention, as they seem to have undergone a peculiar vitreous degeneration at irregular intervals along their whole length. I say at irregular intervals, but perhaps it would be better to say that in some of the fibres the vitreous patches appear at regular intervals along their course, whilst in others, the whole of the muscular elements have become transformed into this peculiar material.

Wherever this change has occurred the fibres are fractured irregularly, usually at right angles to the longitudinal axis of the muscle (Pl. XXIII., Fig. 2). Nearer the cavity the muscle fibres are also markedly atrophied (Fig. 1, *d, e*); they do not measure more than one-fourth of the diameter of the normal fibres. Between the atrophied and degenerated fibres in this position there is an increase in the quantity of connective tissue, which is made up of small round and slightly elongated cells, with a few fibrils and older connec-,

tive tissue corpuscles at intervals. This mixture of atrophied muscles and young connective tissue is gradually lost in what was above described under the naked eye as the "zone of fibrous-looking tissue." This zone consists of "granulation tissue," which is composed of young connective tissue, through which are ramifying numerous embryonic blood vessels (Fig. 1, *c*). A considerable number of these are in the form of loops, the convexity of each loop being turned towards the cavity; others run irregularly and in various directions; and all are distended with blood corpuscles. Although the vessels are relatively fewer as the cavity is neared, numerous blood corpuscles are found in the cavity, in some instances forming a kind of lining. The large free mass lying in the centre or in the cavity (Fig. 1, *a*) is surrounded by a thin zone of young connective tissue cells, with here and there a few blood corpuscles; but blood vessels are not to be seen in any part of this thin connective tissue layer. Surrounded by this delicate outer layer is a large mass made up of small vitreous-looking patches with remains of muscular tissue in an advanced stage of degeneration. The individual fibres are enormously swollen; they have lost all trace of striation; irregular fracture has taken place; and fissures are seen running in all directions. On staining with osmic acid, a few fat globules are brought into prominence; but these occupy only the spaces at the margins of the fibres, and in some cases the larger fissures. The greater part gives no fatty reaction; with methyl violet no waxy or lardaceous reaction is obtained at any point; but with picro-carmine there is a bright translucent yellow reaction, similar to that given with the horny layer of the skin, but with a slight rosy tinge. Between the swollen, fractured, and degenerated fibres there is an evident increase in the number of connective tissue cells. At no point have I as yet been able to find a parasite of any description, either animal or vegetable, though, from the large amount of granulation tissue present, and from the altered condition of the muscular fibres, I was led to search very carefully for some form of parasitic organism. I may mention that numerous parasites were

found in other positions, as in the submucous tissue of the stomach, the gills, etc.

In the smaller masses above described, the microscopic appearances were very similar to those met with in the larger mass, but here the continuity between the two zones of granulation tissue (*i.e.*, that lining the cavity and that surrounding the degenerated muscle mass, Fig. 1, *b*, *c*) is unbroken.

Although the tumour is described as caseous, it appears that this degeneration of the muscle is rather of the form described by Zenker as the waxy or vitreous degeneration, one of the forms of coagulation necrosis. According to Ziegler[1] there is great tendency to the loss of striation of the coagulated muscle elements under certain conditions in the human muscle. He says, "Under various influences," . . . "as after bruising, forcible extension, raising of the temperature, or febrile disease, the muscle substance is here and there disintegrated, and the contractile myosin coagulates into a lustrous homogeneous mass. This mass breaks up into shining flaky lumps." He further says, "It is hardly ever quite absent where there has been copious exudation."

After I had made the above observations I came across a most admirable description of the changes found at the point of inoculation for Fowl Cholera.[2]

M. Cornil describes a condition almost identical with that we have given above.

At the point of injection "the muscle has lost its normal physical characters. In place of being pale, white, or slightly pink, semi-transparent and of a peculiar elastic softness, it is now grey and opaque with lardaceous appearance, apparently dense and hard but in reality quite friable. It may be double or even triple its normal thickness at the part most

[1] Text Book of Pathological Anatomy. Ziegler. Translated by D. MacAlister. Macmillan & Co., London, 1883.

[2] Observations histologiques sur les lésions des muscles determinées par l'injection du microbe du cholera des poules, sur le séquestre et sur la poche qui le contient—A. V. Cornil, Arch. de Physiol., t. x., 1882, p. 615. Les Bactéries et leur rôle dans l'Anatomie et l'histologie Pathologiques des Maladies Infectieuses—A. V. Cornil, et V. Babes. Paris, 1885.

affected, especially in the immediate neighbourhood of the puncture. . . . In the central mass of the tumour, this grey infiltration is most marked, but the altered muscle has still preserved its fasciculated appearance, and it is easy to see with the naked eye, in sections parallel to the long axis of the fasciculi, bands more opaque and yellower, separating the grey fasciculi. The opaque bands resulting from an inflammation of the connective tissue situated between the secondary muscle fasciculi, and the grey fasciculi are neither more nor less than muscular bundles. The lesion is least marked at the periphery of the tumour, so that the grey and opaque bands are irregularly separated by pink or white and semi-transparent muscular fibres.

"One sees, in fact, at the periphery, congestion, and a distension of the vessels with blood, which is not present at the centre of the tumour." . . . "Sections made of a piece of this tissue hardened in alcohol, and examined unstained, present a very characteristic transverse 'fragmentation' of the muscles. Each of the small fragments appears homogeneous, glistening, transparent; it represents a transverse disc, comprising the whole thickness of the primitive fasciculus; and all these fasciculi are divided into a large number of broken fragments separated by obscure interstices, in which one sees the irregular margins of contiguous fragments. These fragments are not usually thicker than the primitive fasciculus that they replace, though it is not rare to find some which are thick, of a greater diameter than that of the primitive fasciculus, and at the two extremities of which one observes an infolding of the sarcolemma which contains them."

Cornil then compares what he describes with Zenker's vitreous degeneration, but points out that in Fowl Cholera there is no extraversation of blood in the altered parts similar to that observed sometimes in Typhoid Fever, and accounts for this by the fact that in consequence of the inflammation of the connective tissue between the primary and secondary muscular fasciculi there is obliteration of the vessels and arrest of the circulation. In the specimen described above, there were seen, on staining with picro-

carmine the primitive muscular fasciculi "divided transversely into a multitude of small fragments. The large bands less coloured" (than the muscular fibres) "represent the connective tissue which separates the secondary bundles, and are occupied by lymph cells and micro-organisms situated in the middle of a reticulum of fibrin."

"The fragments of muscle still possess at intervals their transverse striation. The fragmentation is due to the entrance of micro-organisms into the sacrolemma and to atrophy; to consequent disappearance at intervals of the muscular substance." . . . "It is not rare to see in longitudinal sections of these altered muscles, primitive fasciculi completely replaced, for a certain extent, by lymph cells and microbes, which thus resemble inflamed connective tissue."

After describing the arrest of the circulation in the altered muscle by distension of the capillary vessels with lymph cells, microbes, and fibrin, Cornil gives a most accurate description of the condition observed by me in the muscle of the fish.

"Following these lesions, the muscle altered, as if solidified, becomes compact, lardaceous, opaque, is condemned in its central portion to a local mortification, the circulation going on no longer, its proper tissue being stuffed with a number of organisms pressed one against the other, and are unable to find material sufficient for their nutrition." . . . "There results a 'sequestrum,' a necrosed portion which has been well described to the naked eye by Pasteur, which is isolated from the neighbouring tissues in which the circulation has still been kept up."

He then goes on to point out the various stages through which the different parts of the altered tissues pass, and at the fourteenth or sixteenth day describes a space which surrounds the sequestrum. This is partially filled with droplets of fat, not adipose tissue. Some of these "adhere to the margin, more or less regular, of the sequestrum, which is formed of the vitreous muscular blocks, and by the dead connective tissue. Other droplets are attached to the walls of the living tissue." Within the cavity he describes a

lining layer of vascular embryonic tissue, similar to that already mentioned (Fig. 1 *c*), and at the deepest part of this granulation tissue layer altered muscular fibres (Fig. 1 *d*). The irregular outline of both sequestrum and cavity are also observed in both fowl and fish.

In the fowl gradual absorption of the sequestrum takes place, when once it becomes completely detached from the surrounding tissues, but this may take several months, and, whilst this is going on, "the fragments have become very friable, they are readily broken down, and form in part a kind of caseous magma." . . . "The older the sequestrum, the greater is the tendency of the blocks to lose their striation." Following this there is disintegration, fatty degeneration, and gradual absorption by the granulating surface.

Cornil speaks of the cyst wall surrounding the sequestrum as consisting essentially of granulation tissue, and the older forms of organising tissue. He says there are three layers:—

1. "An internal layer, continuous with the *débris* of the sequestrum, and in which one finds giant cells of special forms." (These were not present in the specimen under our notice.)

2. "A middle layer composed of large fusiform or branching cells.

3. "An external layer formed of embryonic connective tissue, which is continuous with the pectoral muscle. This deep layer is traversed by numerous blood vessels."

By the aid of the granulation tissue with its actively digesting cells, the sequestrum is gradually absorbed, after which cicatrisation takes place.

I have quoted much more freely from M. Cornil's paper than I am perhaps justified in doing, but the singular resemblance between the two processes must be my excuse.

It is quite possible that in the specimen before us we have no micro-organismal origin, but it is certainly more than probable that micro-organisms, though not to be found at this late stage of sequestrum formation, have still been present at some earlier period. A reference to Figs. 1 and 2, will show at once that the processes have ended in much the same way. The altered muscular fibres in the

sequestrum, the several layers of granulation tissue, the altered muscular fibres in the deeper layer of the capsule, and the altered muscular fibres outside, showing the earlier changes in and between the muscles, are all very characteristic, so that although no micro-organisms are to be distinguished at this stage, we cannot be sure that they have not been present, in fact we are almost compelled to arrive at an opposite conclusion. It must be remembered, however, that physical characters here come in to assist in giving rise to the appearances presented. The degeneration of the muscle fibres brings about a complete loss of contractile power and of elasticity. The muscles surrounding them, still retaining their contractility, draw upon the inelastic mass, and fracture takes place in various directions, and as the granulation tissue grows between the muscles, they become atrophied and can no longer contract, whilst those outside still draw irregularly on the outer layer of granulation tissue, and thus assist in all probability in separating the granulation layer from the softened or softening sequestrum within. Not only so, but the presence of the mass of dead muscle undoubtedly acts as an irritant, and so helps to bring about the formation of the extremely vascular granulation tissue. The fact that there is material to be absorbed, stimulates the tissues to the formation of an absorbing membrane.

If the mass is not of parasitic origin, the only other possible explanation appears to be that the coagulative necrosis has been set in during life, after some violent muscular exertion, the only fact in support of this being that most of the masses were found in the muscles which are most frequently and most violently exerted.

Here the changes are explicable on the theory that the coagulated muscle elements become fractured, are separated from the surrounding muscular fibres, and that they by their presence as dead material act as irritants; a granulation tissue is formed between and around them; and they are gradually absorbed.

Should opportunity offer, I hope that Fellows of the Society will place parts of similar morbid masses in my hands, in order that I may continue the investigation.

Description of Plate XXIII.

FIG. 1.

Section of small portion of capsule and one of the larger sequestra, stained with osmic acid (× 60).

(*a*) Sequestrum composed of vitreous masses of muscular fibres ; the areas are well seen, and the fragmentation is well marked.

(*b*) Thin layer of connective tissue in immediate contact with the sequestrum. This is granular and fatty, and in many cases consists merely of a mass of *débris*. Outside this is a well-defined space or fissure.

(*c*) Layer of vascular granulation tissue with larger cells near the fissure, and with well-marked vascular loops throughout. Beneath this the tissue is denser, cells are more fusiform or branching, and larger vessels are found.

(*d*) Fibrous or fibro-cellular layer, in which are enclosed numerous atrophied muscular fibres, represented by the dark patches.

(*e*) Vitreous muscular fibres outside the capsule altogether.

FIG. 2.

Longitudinal section of some of the hyaline muscular fibres, in the earlier stages of the process, taken from just outside the capsule. Stained with osmic acid (× 400).

(*a*) Striped muscular fibre, quite normal in appearance.

(*b*) Portion undergoing the vitreous or hyaline fragmentation. In this mass small globules of fat, stained black with osmic acid, may be seen.

(*c*) Fibre in which fragmentation and vitreous degeneration is more general.

(*d*) Inter-muscular connective tissue, only slightly increased in quantity.

XLI. *Caseous Ulcer in Skin of Cod.* By G. Sims Woodhead, Esq., M.D., F.R.C.P.Ed. [Plates XXIII., XXIV.]

(Read 20th May 1885.)

In a previous paper on Degeneration in the Muscles of a Fish, it was pointed out that there was first a vitreous change, which, however, was almost invariably followed by a true caseation. Through the courtesy of Ben. Peach, Jun., Esq., F.R.G.S., I am enabled to place before the Society a very good example of caseation in the skin and deeper tissues of a cod, leading to ulceration, destruction of the periosteum, and complete disorganisation of the joints at the bases of the fin rays.

The portions of the fish sent to me were a pectoral and a ventral fin cut out with a penknife from the left side of a

cod, which, says Mr Peach, "was evidently in very poor condition. There were ulcerated patches on the same side, one of them, about two inches in diameter, in a line with the pectoral fin and a few inches behind it. . . . There were several other smaller ulcers nearer the tail."

The portions sent to me were placed at once in Müller's fluid, in which they were exceedingly well preserved, until I had an opportunity of examining them.

On examining the fin and tissues over the pectoral arch, which have been cut away with the fin, a large ulcer is seen in the fold of the skin on the extensor surface of the joint. It measures 1¼ in. in diameter from above downwards, 2 in. from before backwards, and extends over the upper three-fourths of the breadth of the fin at its base. The ulcerating margin is soft, friable, and caseous or cheesy looking.

This cheesy margin is about three-quarters of an inch in breadth, the free margin being much more granular and friable than the attached portion, which is somewhat more cheesy and tenaceous in consistence.

The lower border of the ulcer is very considerably thickened, is not caseous throughout, but is gelatinous. In the gelatinous mass is embedded a peculiar caseous nodule. A small piece of this was removed and examined under the microscope, the result of which examination is given below. In the floor of the ulcer itself the bones of the pectoral arch and the bases of the fin rays are completely bared, as not only is the pereosteum removed, but the ligaments and the whole of the structures round the articulations are completely disorganised, so that the proximal ends of the fin rays are quite free. There are still small fragments of caseous material scattered over and attached to the bones, these pointing to the fact that caseation probably preceded the ulceration in the whole area. At the tip of the fin is a similar but smaller ulcer. Near the larger ulcer, but not involved in the caseous margin, are a couple of small round nodules, one of them $\frac{1}{12}$ in. in diameter, with a raised, slightly umbilicated centre, and a depressed margin. This tubercle is not cheesy, but is dark brown in colour and slightly gelatinous in the centre, though it is certainly not

like an ordinary tubercle nodule to the naked eye. At the opposite margin of the ulcer is a similar but smaller nodule, about $\frac{1}{20}$ in. in diameter. Microscopic examination of a small portion of the thickened margin of the ulcer disclosed a condition almost identical with that observed in gummata and allied degenerated masses of tissue. Where the cheesy condition is not well marked, the bundles of muscular fibre are separated by numerous small round cells, almost like those met with in granulation tissue. The muscular fibres themselves are somewhat atrophied, and are frequently divided into comparatively short lengths; between them small collections of granular material, and here and there large well-formed cells, some of which have more than one nucleus, are found. These cells are very like the endothelioid cells so frequently met with in all tissues where there is any tendency to fibrous tissue formation.

The most important changes, however, are observed in the blood vessels, and in order to make these changes more comprehensible it may perhaps be well to describe very briefly the structure of a blood vessel of a fish.

As in a vessel of the human subject there are three coats: the *Tunica adventitia*, or outer coat (Pl. XXIV., Fig. 3 *a*), which in this position is of very considerable thickness. It consists essentially of a dense network of connective tissue, in which are a few nucleated cells. This connective tissue coat may be said to be continuous with that of the surrounding tissues, and any morbid process taking place in the one, will in all probability be continued into the other. Within this outer coat is a well-marked middle coat, or *Tunica media* (Fig. 3 *b*), composed for the most part of circular bands of non-striped muscular fibres. Within this middle or muscular coat there is a distinct line of demarcation between it and the internal coat, or *Tunica intima.*

The internal coat is composed of two layers:—first a layer of flattened connective tissue made up of laminæ of fibrous tissue, between which, usually seen in section as spindle-shaped cells, are flattened branching connective tissue cells. Inside this is a layer of flattened endothelial cells, which forms the smooth glistening lining of the vessel

(Fig. 3 *c*). The vein differs from the artery in that the muscular coat is very much thinner, and the outer coat is usually not so well developed.

On examining the vessels in the area above mentioned (the small piece taken from the thickened margin of the ulcer), the following appearances are present. As one would expect from the infiltration already observed in the connective tissue between the bundles of muscular fibre, there is marked infiltration of the outer connective tissue coat with small round cells. These small cells consist almost entirely of a nucleus, the film of protoplasm around them being very thin indeed. There are, however, along with the small cells, a number of large, well-formed, usually rounded connective tissue cells, in which the formed material around the nucleus is present in considerable amount. Some of these cells have several nuclei.

The muscular coat is as a rule not much altered, but occasionally one finds a slight increase in the number of small round cells in this position.

It is on the internal coat, however, that the most marked changes are seen; in the present instance it is enormously and irregularly thickened. In the thickened portion the laminæ are arranged apparently not in the same plane as the circumference of the vessel but at right angles to it, and the cells seen in section as they lie between the laminæ, run with their long axes at right angles to the plane of the circumference. A similar arrangement is sometimes observed in syphilitic *arteritis obliterans* (Plates XXIII. and XXIV., Figs. 4 and 5). As may be seen on reference to Fig. 4, the thickening is very irregular, and in consequence the lumen of the vessel is unequally narrowed. This condition very closely resembles not only *arteritis obliterans* as seen in syphilis, but also in stonemason's phthisis, chronic tubercular phthisis, in healing wounds, interstitial nephritis, and the like. In all these processes, there is eventually a cutting off of the blood supply from tissues which were originally supplied by the arteries. It appears as though an exactly similar process is here taking place. In the section under examination numerous transverse (Fig. 4) and longitudinal sections of vessels

are seen, in which still further changes are taking place. The muscular coat is still fairly well defined, but in it are numerous small round cells similar to those mentioned above, each consisting of a nucleus and a very thin film of protoplasm.

What corresponds to the inner coat is now seen to be simply a vitreous or caseous mass, which is evidently composed of the proliferated cells of flattened layers and of the altered formed material which lies between the cells. The lumen of the vessel is completely occluded; blood could no longer pass to supply the vessel walls and the tissues to which they run. After a careful examination of these obliterated vessels in both longitudinal and transverse sections, one is forced to the conclusion, that what we have described is taking place in a great number of the small arteries. The whole of the obstruction is not necessarily due to thickening of the inner coat, for in some of the sections examined the remains of a small blood clot could be seen filling up what remained patent of the lumen, completing the occlusion. Here, then, we have a definite course of events. Be the cause what it may—and the evidence points strongly in the direction of Parasitism, though as yet no actual micro-organism has been distinguished in this position—there is inflammation of the walls of the vessel leading to infiltration of the *T. adventitia* with small round cells, to less marked changes in the muscular coat, and to extremely well-defined changes in the inner coat, which becomes enormously thickened; in consequence of this thickening, the lumen of the vessel becomes very much diminished, the wall is no longer smooth and regular, and eventually a blood clot is formed in the narrowed tube, which is thus effectually closed; what follows, is what would be expected under the circumstances. The walls of the vessels are considerably altered, but although there is such a great increase of cellular tissue, there is no corresponding increase in the number of blood vessels or in the nutritive supply to the walls of the vessel, consequently when the clot is once formed it is practically cut off from all food supply, and the altered *T. intima* is similarly situated. The clot in the centre of the patch first undergoes caseation, or

some similar change; it becomes hyaline, swollen, then granular; and at this stage takes on the yellow picric acid stain of picro-carmine. Around the central hyaline or caseous clot, the thickened inner coat may be distinguished for some time, but eventually the cells in this position begin to swell up, they gradually become hyaline, run together, and then assume a granular appearance, taking on the characteristic yellow stain, to which reference has already been made. The vascular supply has been cut off not from the walls of the vessel only, but also from the areas which were supplied by these vessels. Hence we see in the cut specimen large tracts of tissue in which the cells are hyaline, swollen, and in many cases running together, just as we have seen them in the walls of the vessels. The fibres are also swollen or granular, so that large homogeneous or granular masses, stained yellow with picro-carmine, are seen, corresponding in their distribution with that of the obliterated vessel.

It is in consequence of these changes that the ulceration described takes place. The degenerated tracts get larger and larger, they gradually run together, and the soft granular material disintegrates, leaving ulcerated patches, which in turn get larger and run together to form ulcers of the size detailed at the commencement of the paper. The processes mentioned above as preceding the ulceration are of course best marked at the margin of the ulcer, the advanced caseous patches at the extreme margin and the inflammatory changes some little distance away from this point.

The process of caseation is very similar to that observed in the conditions associated with tubercle, syphilis, and the like, and the results as seen under the naked eye are very like one another.

It should be observed, however, that here there are no giant cells. Taking one of the vessels as an example, there is the well advanced caseous clot in the centre, surrounding this are endothelioid cells or plates lying on a species of reticulum, both cells and fibres growing in connection with the laminated layer of the inner coat of the vessel. Even in the degenerating areas outside the vessels altogether, not a single giant cell could be made out.

As yet, after a patient search, no micro-organisms have been found, but the evidences of their presence at some time or other as seen in the changes in the tissue elements are very strong indeed.

Description of Plates XXIII. and XXIV.

FIG. 3.

Longitudinal section through small healthy artery taken from base of Fin of Cod. Preserved in Müller's fluid stained with picro-carmine (× 300).

(*a.*) *Tunica adventitia*, or outer connective tissue coat, composed of white fibrous tissue forming dense felted wavy mass.

(*b.*) *Tunica media*, or middle coat, composed of circular non-striped muscular fibres. The nuclei and outlines of the fibres, cut transversely, well seen at the upper part of the figure; the outlines of the circular fibres are well seen.

(*c.*) *Tunica intima*, or inner coat; the laminated fibrous tissue well seen, but the flattened connective tissue and endothelial cells are not shown in the drawing.

A few nucleated blood corpuscles are seen lying in the lumen of the vessel.

FIG. 4.

Transverse section across two branches of a small artery just below the point of bifurcation of the parent vessel in the thickened gelatinous margin of the ulcer at the base of the Fin (× 80), stained in picro-carmine.

A. In this branch obliteration is not complete.

(*a.*) Infiltrated adventitia, especially around the small *vasa vasorum.*

(*b.*) Muscular coat little changed.

(*c.*) Inner coat, irregularly thickened. Here the cells lying between the fibres are well seen and also the axis in which they lie.

B. In this branch the obliteration is complete and degeneration has commenced.

(*d.*) Altered muscular coat. Muscular fibres atrophied or degenerating. Increase of interfibrillar nuclei.

(*e.*) The vitreous inner coat is here very well seen.

FIG. 5.

Section through small part of wall of vessel. (Plate XXIV., Fig. 4 A.) × 400.

Here the enormous proliferation of the cells of the inner coat is well seen.

(*a.*) Represents position of lumen of vessel. The endothelial layer has been removed.

(*b.*) Represents laminated layer with axis of cells at right angles to circumference.

(*c.*) Muscular coat.

In this part of the vessel the degenerative changes have not yet commenced.

XLII. *On the Chemical Composition of some Samples of Scotch Ensilage.* By W. IVISON MACADAM, Esq., F.C.S., F.I.C., Lecturer on Chemistry, School of Medicine, and Professor of Chemistry, New Veterinary College, Edinburgh.

(Read 18th March 1885.)

During the present agricultural depression any subject or method which promises more or less to aid a hard-working and, for some year's past, heavy-losing class of men is looked upon with special interest. Should the first results of experimental trials appear satisfactory, the tendency is to cause other members of the same class to lay out capital in plant, etc., and so endeavour by means of the new digression to fill the already almost empty coffers.

No subject has at the present moment greater interest to the agriculturist than that of silage, or the means by which freshly cut grass or grain may be retained for a longer or shorter period in a state fit to be employed for feeding purposes, without the labour employed in sun-drying or haymaking. The subject becomes all the more important when the uncertainty of weather and durability of sunshine are taken into account.

The process of *silage* requires a considerable outlay of capital, because the grass or other material to be converted into *ensilage* must be excluded from the air, and consequently special buildings must be erected. These compartments are known as *silos.*

The most primitive and, at the same time, successful method seems to be that long used by the German Landwehr of digging a pit, in which the grass or other material is placed, and afterwards covered with loose boards and an outer layer of earth.

More complex arrangements consist of buildings built under ground and having apparatus attached for the after loading or pressing into a semi-compact state of the ensilage.

Attempts to utilise old farm buildings, such as barns, have proved failures, until such time as the walls, roof, and floors

have been coated with an air-tight skin of cement—*the exclusion of air being a necessary condition of success.*

The samples of ensilage to which I am desirous of directing your attention are five in number. Nos. 1 and 2 are from silos constructed in Midlothian, whilst the remaining samples come from the neighbourhood of Arbroath.

Nos. 1 and 2 samples consisted of very coarse herbage, being a mixture of grasses with reeds, rushes, etc., and with one or two of the flowers (Ranunculaceæ, etc.), which are found in low or boggy ground.

No. 3 sample was labelled as "*a mixture of rye-grass and clover,*" and contained, besides the Loliums, other grasses, especially Hordeums, Poas, Holcus, and Dactylis, with Trifoliums and other flowering plants, especially members of the Ranunculaceæ.

No. 4 sample was "*a mixture of green barley and old pasture.*" I have identified Poas, Phleum, and Holcus, but the condition of the material and the few flowering heads present renders the naming of species difficult.

No. 5 sample was one made from the cuttings of the "*grass from lawns,*" and contained the usual Poas, Holcus, Phleums, Festuca, etc.

In making the analyses of these samples, the usual methods were followed,—the substances determined being the percentages of moisture, ether extract (or fatty and acid substances), albuminous substances as determined from the nitrogen present, starch, gum or mucilage and sugar, woody fibre, and ash or mineral matter. The results are given in Table A.

It is difficult to compare these results with each other, or with fresh grasses, as the proportion of moisture present varies to so great an extent, and I have therefore recalculated the results as free from that ingredient. The figures are to be found on Table B.

On comparing these results with those given in Table C (the results of the analyses of forage grasses as given by various chemists) it will be noted that the ensilage differs much from the fresh material. The oil or ether extract is higher in the ensilage, whilst the albuminous compounds are

lower. The ash also is higher. It is true that the two tables are scarcely in a position to be compared, for they do not represent the same field of grass, and moreover they do not represent the same mixture of grasses. It is well-known by agricultural chemists that even the same variety of grass differs in composition according to the age, approach or otherwise to flowering, soil, height above sea-level, and even climate. Still the average figures may be employed, and the results of such a comparison is as stated above.

An endeavour to further corroborate the figures as to the proportion of nitrogen present, and from that the albumenoids, using dried portions of the ensilage, led to results so different from those obtained with the fresh moist sample that other experiments became necessary. The results obtained when the moist material was used agreed with those first found, and further trials with dried samples showed that a considerable loss of nitrogen was sustained during the drying operation. The results are given in Table B, where it is shown that whilst in No. 3 the total nitrogen present in the moist sample was 1·319 per cent., that after drying only 1·063 per cent. was retained, showing a loss of nitrogen from the total amount of 0·256 per cent., or about one-sixth. No. 4 shows a still greater loss, for whilst the total nitrogen was equivalent to 1·543 per cent., the nitrogen in the dried portion was only 1·030 per cent., or a loss of 0·513 per cent., equal to about one-third. No. 4 sample lost nearly one-half of its nitrogen on drying. The volatilisable nitrogen could not be present in the state of albumenoids or flesh formers, but was evidently in the form of amides, if not actually of ammonia. This volatile nitrogen therefore should not be reckoned as albumenoid, and consequently the results obtained from the nitrogen of the moist ensilage were not representative of the albumenoid of flesh-forming material present in the ensilage. Table A therefore, although calculated by the usual methods, is not correct, and conveys a wrong impression as to the feeding value of the ensilage. It is the nitrogen left after drying that should be calculated into albumenoids, or in other words, the ensilage should be dried before being analysed or a second nitrogen estimation be made

to show the amount of non-albumenoid nitrogen. The analyses after the necessary recalculation will be found on Table D.

On Table E is given the results of analyses of fresh and siloed Lucerne as made by Weiske and others (Bied. Centr., 1884, pp. 464-469), and as extracted in the Journal of the Chemical Society of London. The author, however, does not seem to be aware of the presence of nitrogen as ammonia, although the results show a decrease in the albuminous compounds after silage. The proportions of albumenoid material there given are high, and may be accounted for by the author having overlooked the presence of free ammonia. Weiske says that "the analyses were conducted in the usual way after the silage had been extracted with cold water," the reason for the extraction being given in the following part of the clause, "and the volatile acids (butyric) estimated in the extract by volatilisation, and the non-volatile (lactic) by titration." It thus appears that the reason for digestion in water was for the purpose of estimating the acidity, and no mention is made (in the extract quoted) as to volatilisable or saline ammonia being in the ensilage.

A further study of Weiske's results shows that the starch group has also decreased during silage, and that the ether extract has increased much. This last fact is well brought out in Table D as compared with Table C. Consequent on the above changes in composition, we find an increase in the percentages of fibre and mineral matter or ash. This loss of dry matter appears from the above results to vary very much, running in some cases as low as 10 per cent., but in others being as high as 40 to 50 per cent. of the fresh grass.

The nitrogen can only be derived from the splitting up of the albumenoids, for this is practically the only compound of nitrogen in the plants. True, according to Herren Bungener and Fries (Bied. Centr., 1884, pp. 406-409), a proportion of amide nitrogen is present in the grain of barley, but the total in the dried sample did not exceed so small a proportion as to be overlooked. All the analyses of grasses yet published in this country—and they are few—show no

nitrogen as ammonia present in the fresh plant. Bungener and Fries' results are on Table F.

The fall in the proportion of starchy material is accounted for by the presence of lactic and butyric acids in the ensilage. Weiske states the proportion of lactic obtained from a lupine ensilage at 2·30 per cent., and the butyric acid at 3·58 per cent., the latter figure being increased in other analyses to 7·45 and 7·34 per cent.

It would thus seem that during the process of converting grass into ensilage that a fermentation developing butyric and lactic acids takes place, and that at the same time a decomposition of the albumenoids proceeds, leading to a loss of feeding power and the formation of ammonia.

The feeding power of the ensilage is impaired by these changes, and according to Tables D and C the flesh forming power is only about three-fifths that of meadow hay. In Table E the starch compounds are only about three-fourths those of fresh Lucerne. It will therefore be necessary to consider these points when ensilage is to be used for feeding purposes. The strong and most disagreeable odour of the ensilage is known to all who have seen the few silos erected in this country, and so pungent is this smell, that even cattle object to it at first, although after a time they may be induced to take the material somewhat greedily.

Great care is necessary in opening the silos to admit as little air as possible, for further decomposition rapidly ensues, and the material becomes musty and improper for feeding purposes.

TABLE A.—Chemical Composition of Ensilage.

	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Moisture, . . .	76·32	73·71	68·71	72·07	74·92
Oil, ...	1·33	1·11	1·25	1·51	2·01
*Albuminous Compounds,	1·73	2·31	2·58	2·79	3·46
Starch, Gum, and Sugar,	13·88	14·96	14·73	13·36	11·12
Woody Fibre, . .	4·83	6·04	9·86	7·42	5·86
Ash, ...	1·91	1·87	2·87	2·85	2·63
	100·00	100·00	100·00	100·00	100·00
* Nitrogen, . .	0·278%	0·369%	0·413%	0·431%	0·554%

TABLE B.—Chemical Composition of Ensilage.

Calculated as free from Moisture.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Oil,	5·61	4·22	3·99	5·41	8·01
*Albuminous Compounds,	7·31	8·78	8·24	9·98	13·79
Starch, Gum, and Sugar,	58·61	56·91	47·07	47·83	44·33
Woody Fibre,	20·39	22·97	31·51	26·56	23·36
Ash,	8·06	7·11	9·17	10·21	10·48
	99·98	99·99	99·98	99·99	99·97
* Total Nitrogen,	1·174%	1·403%	1·319%	1·543%	2·209%
Nitrogen Volatilised on drying the Sample,	0·410	0·851	0·256	0·513	1·177
Nitrogen in dried Sample,	0·764	0·552	1·063	1·030	1·032
=Albuminous Compounds,	4·775	3·450	6·643	6·437	6·450

TABLE C.—Chemical Composition of Forage Grasses.

Calculated as free from Moisture.	Average of 18 Species. (Warg.)	Average of 21 Species. (Ritthausen & Scheten.)	Meadow Hay. (Johnson & Cameron.)	Lolim Perenne. (Warg and Ogston.)	Lolim Stalicum. (Warg and Ogston.)
Oil,	3·06	2·47	3·29	3·18	3·27
*Albuminous Compounds,	11·05	9·17	10·82	11·79	10·04
Starch, Gum, and Sugar,	45·64	41 29	48·28	42·28	57·85
Woody Fibre,	33·53	40·00	30·35	35 21	19·79
Ash,	6·72	7·06	7 29	7·53	9·08
	100·00	99·99	99·98	99·99	100·03
* Nitrogen,	1·768%	1·467%	1·571%	1·886%	1·606%
Water in Fresh Sample,	68·3	70·3	...	71·43	75·61

TABLE D.—Chemical Composition of Ensilage.

Analysis of Dried Sample.	No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
Oil,	5·75	4·45	4·05	5·61	8 66
*Albuminous Compounds,	4·47	3·45	6·64	6·43	6·45
Starch, Gum, Sugar, etc.,	60·13	60·11	47·83	49·59	47·84
Woody Fibre,	20·92	24·26	32·02	27·53	25·21
Ash,	8·27	7·51	9 32	10·59	11·31
	99·54	99 78	99·86	99·75	99·47
* Nitrogen,	0·764%	0·552%	1 063%	1·030%	1·032%

TABLE E.—Chemical Composition of Lucerne Ensilage.

(Weiske, etc., Bied. Centr., 1884, pp. 464-469).

	Siloed Close.		Slightly Pressed.		Not Pressed.	
	Fresh.	Silage.	Fresh.	Silage.	Fresh.	Silage.
Oil (Ether Extract), .	4·44	8·79	4·91	8·58	5·01	6·75
Albuminous Compounds,	26·69	23·35	25·94	21·44	25·00	20·94
Starch, Gum, and Sugar,	37·12	28·42	37·32	26·83	37·52	30·20
Woody Fibre, . . .	22·54	28·03	22·90	30·40	23·57	29·62
Ash, ...	9·21	11·41	8·93	12·75	8·90	12·49
	100·00	100·00	100·00	100·00	100·00	100·00

TABLE F.—Barley and Malt.

(Bungener and Fries, Bied. Centr., 1884, pp. 406-409.)

Nitrogen.

	Barley.	Malt.		Barley.	Malt.	
Total Nitrogen in Dried Sample,	1·69	1·58		1·84	1·73	
Total Nitrogen Soluble in Water,	21·0	40·6	36·7	20·6	36·2	36·4
As Albumenoids, . . .	9·5	14·5	10·3	21·1	14·4	10·6
Peptones, ...	2·4	3·8	5·0	2·2	2·4	3·5
Amides, ...	19·1	22·3	21·4	6·3	19·4	22·3

XLIII. *Note on the Presence of Certain Diatoms in a Town Water Supply.* By W. Ivison Macadam, Esq., F.C.S., F.I.C., etc., Lecturer on Chemistry, School of Medicine, and Professor of Chemistry, New Veterinary College, Edinburgh.

(Read 15th April 1885.)

The presence of these minute forms of vegetable life in fresh and salt waters has been long recognised, but the number of specimens to be obtained from any one sample of water has generally been very small. In the case to which I beg leave to direct your attention, the water is of excellent quality for domestic use, is soft in character, and contains only very minute proportions of ammonia. The chlorine is merely a trace, and nitrogen, as nitrates or nitrites, entirely absent. As, however, the water is collected from running streams, it is liable to contain in mechanical suspension more

or less flocculent solid particles, partly organic, but to a greater extent mineral in nature. To cause the removal of this solid suspended matter filtration has been resorted to; the filters employed being made in the usual manner with gravel and coarse and fine sand When put into use these filters were noticed to become very rapidly covered with a coating of green slimy matter, which in time caused more or less choking of the apparatus, and rendered frequent cleansing necessary.

The chemical examination of the dried scum or skin which had formed on the surface of the sand disclosed the fact, that, even after the most careful preparatory cleansing of the sample to remove adhering sand, the material was to a very large extent composed of a mineral residue which was insoluble in acids, but was readily volatilised by the addition of hydric fluoride. The microscopic examination of this residue revealed the fact that the material was made up of diatomaceous valves, in a state of almost absolute purity.

A purified sample of the valves was forwarded to Mr E. Groves of Saltburn, who kindly undertook the microscopic determination of the species, and who reports that the sample consists almost entirely of *Fragilaria capucina*, Desm., and that "the filaments are matted together in enormous abundance, but when treated with acid they break up completely into single valves." The following is a list of the species identified, all of which, with the exception of the Fragilaria, were present only in very small quantity:—

Fragilaria capucina, Desm
Amphora ovalis, var. *affinis*, Kg.
Cymbella lanceolata, Ehr.
,, *Cistula*, Hemp.
,, *affinis*, Kg.
,, *cuspidata*, var. *anglica*, Lg.
Encyonema caespitosum, Kg
,, *turgidum*, Greg.
Navicula radiosa, Kg.
Achnanthes lanceolata, Kg.
,, *minutissima*, Kg.
Cocconeis Pediculus, Ehr.
Cymatopleura Solea, Sm.
Nitzschia linearis.
,, *sinuata*, var. *tabellaria*, Grun.
Synedra ulna, var. *danica*, Kg.
Melosira varians, Agh.?

The deposit is interesting from the presence of so large a proportion of the *Fragilaria capucina*, which, whilst it is by no means an uncommon species of Diatom, yet is usually very largely mixed with other species.

The question as to whether the presence of these Diatoms is in itself hurtful, or points to contamination of the water in which they are found, is a point of some importance. It is a well-known fact to all those who are experts in water analysis, and in the examination of streams for pollution, that the presence of vegetable life is not in itself hurtful provided it consists of those forms, mostly green in colour, found in pure waters. It is also admitted that where a water becomes contaminated with putrescent matters, the character of the flora entirely changes. The Diatomacea belong to the first of these classes, and are especially found in waters which have for their collecting ground rocks of an igneous or metamorphic origin. They are therefore rather an evidence of the purity of a water supply, and their presence need not be the cause of any alarm. A properly constructed sand filter will readily cause their removal.

XLIV. *The North-West Coasts of Sutherland and their Bird Life.* By JOHN A. HARVIE-BROWN, Esq., F.R.S.E., F.Z.S., etc., President.

(Read 20th May 1885.)

The district about which I intend to treat in the present paper is one little spoken of by naturalists. It extends from Rhiconich round the shore, following the deep sea loch of Inchard, including the coast between that and Cape Wrath, and the outlying islands of Bulgie and Rona, and other rocks and skerries; and again eastward from Cape Wrath to Whiten Head at the eastern entrance to Loch Eriboll.

After traversing the long stage between Lairg and Durness on the 9th June 1882, a drive of upwards of 60 miles, I took up my quarters at Durness, from which point I intended to visit the north coast.

I passed through the wild strath of Dionard. The Edderachyllis district of Sutherland somewhat alters in its physical aspects when the traveller gets north of Loch Laxford. He sees no more of the richly-clad birch slopes round the lochs by the road side, so common south of Scourie, but instead, he

notes the stonier, barer, and less productive land; and though the lochs bear water-lilies and their leaves upon their surface, scarcely any birch growth is seen upon their sides. Altogether the country is drearier, more sad-looking than Assynt. This dreariness increases as the traveller passes on leaving Rhiconich behind, and when he reaches the highest part of the road between that and Durness, about Gualinn Shooting Lodge, at the head of the melancholy Strath of Dionard. The traveller has also seen less of the sea, the road winding between the stony ice-scraped hills, and traversing shallow bogs in the hollows, out of sight for the most part, of the sea. Passing Gualinn House, which rests on the crest of the watershed, we drove slowly on past the little fished lochs of Scarbhach More and Loch na Sgeir, and descended into the dark valley. Dismal, indeed, and weird is this wild valley of Dionard or Grudie, the shadows falling from cloud and hill-top in universal gloom on this the day of our first acquaintance with it, the sole redeeming light being that of the winding river Grudie, as it caught up a few last rays from the northern sky, and wearily wended its sluggish course seaward. I know of no valley in all Sutherland so weird in its utter loneliness as this; and a silence as of death reigns over and around it. Looking back after traversing some 6 miles of its length, I could see, perched like a dove on a sloping house-top, the Lodge of Gualinn, looking no bigger than a man's hand against the sky.

At last, skirting the Kyle of Durness, and then crossing over to the eastward, we landed at the Cape Wrath Hotel of Durness, and were welcomed by our kind and genial host—Mr Dunnet.

The next day I took a leisurely walk round that part of the coast included by the Far-out Head peninsula. There is nothing remarkable in this coast to distinguish it from the general characteristics of the north-west coasts, but the view from above the hotel takes in all the more important bits of scenery. At Seanachastail—where there are supposed to be visible the remains of an old castle—a good view can be had of the shore and of the somewhat prominent stack of Clachbeag. Further on, and nearly opposite Clachbeag, another

landscape is taken within the compass of the eye, and a good view of the stack itself is obtained. With a good binocular I could see the several species of birds which breed upon it. A very large colony of puffins breed upon the sloping top of Clachbeag which faces south-east. On its south extremity is a colony of Green Cormorants (*Phalacracorax graculus*),—say fifteen pairs,—and in numerous little niches and shelves are guillemots and razorbills, the latter more numerous than the former. A pair or two of greater black-backed gulls (*Larus marinus*) were made out amongst the puffins. Herring gulls (*Larus argentatus*) have a colony on the inner and lower rocks, and in scattered pairs about the larger Clach (literally a round-topped lump). A few lesser black-backed gulls (*Larus fuscus*) were also flying about. A pair of peregrines kept screaming overhead, and a pair of oyster-catchers made their presence known. On the rocks below me rock pipits were very abundant, and on the grassy ground of the interior of the peninsula meadow pipits were almost equally plentiful, whilst skylarks were also common; and I saw a few corn buntings. Sparrows are in Durness and at the farm steading of Balnakeil and at the Durness Manse, but are not very plentiful. Flocks of immature herring gulls were feeding or resting on the far-stretching sands of Balnakeil Bay. Amongst the abrupt faces of the sandhills broken by the tides,—often broken as if cut down by a spade,—where the roots of the marram grass or bents made a thick matted screen or cover, I searched in vain for a nest of the Twite (*Linaria montana*), nor did I get a glimpse of a bird. In North Uist similar favourable ground is thickly populated by this interesting species.

My friend, Mr Allan Scott of Balnakeil Farm, tells me he knows of one rabbit upon the peninsula of Far-out Head. How or when it came there he cannot tell. It frequents the stony ground and broken slopes of the hills at Far-out Head facing the east.

During our drive from Rhiconich yesterday, I observed the whinchat to be common here and there. The wheatear is also abundant, but scarcely so much so as it is in the Assynt limestone ranges; and it is hard to say why it is less

so on the Durness limestone, where apparently a very similar flora exists. *Dryas octopetala* is abundant around Durness, and so is *Primula scotica*, and the former is almost equally abundant at Inchnadamph in Assynt.

During one or two short excursions made in company with the Messrs Scott of Balnakeil, whose great hospitality and kindness I can never forget, I visited other portions of the coast in the vicinity of Durness. At one place, a little to the west of Balnakeil, and between it and the entrance of the Kyle of Durness, I was shown a peculiar "swallow" or *creux* in the level land about 200 yards from the shore. It is about 90 feet deep, and the sea runs up a long chasm and cave and fills the bottom. It is said that a boat can pass up this chasm and through the cave in fine weather.

On another occasion we visited the far-famed Smoo Cave, and I lit it up by means of magnesium wire. I do not intend to describe the Smoo Cave in this place, but will refer you to what is perhaps the only good description of it, by my friend Dr Heddle, in the *Geognosy and Mineralogy of Scotland*, Part viii., pages 257-262.

During my stay at Durness, I also devoted a large share of my attention to the varieties of trout found in the lochs and streams of the district, and in this I was very largely assisted by my friend Mr D. Mackay of Portnacon, a local naturalist of talent and ability, and having an intimate knowledge of the botany, geology, and zoology of the country around. One of the results of these inquiries was the discovery of a variety of trout, which Dr Francis Day informs me, after examining specimens which I forwarded to him, are more nearly related to Loch Leven trout than any other link he has seen, having the coecal appendages intermediate in number between *Salmo fario* and *Salmo levenensis*, and being as silvery in appearance in the juvenile stage as sea-trout. These will be found fully described in Dr Day's fine new work upon British Fishes. Several other interesting notes on varieties, and the success of introduction of trout to fishless lochs, etc., were noted by me; but I must not at present diverge too much from the object of this paper,

though, possibly, on a future occasion, I may arrange them and read them to the Society, along with much interesting matter gathered in conversation with Mr Mackay.

My next excursion was to Whiten Head, choosing a fine calm day—the 17th June. I drove over to Rispond at the western side of the entrance to the long reaching Loch Eriboll, and thence hired a boat to go to Whiten Head, the caverns in the quartzite of which are remarkably fine. Owing to the remains of a heavy surf and swell from the north after the late gales, we could not take the boat far into the caves and galleries, many of which are united by passages parallel with the cliff face, or branch off in many directions. It requires a perfectly calm day after a week's wind from the south,—or off the land,—before the exploration of these great sea-caverns can be effected in safety.

Bird life is not abundant as compared with that at our famous sea-fowl nurseries, but the caves hold numerous green cormorants and a few—apparently very few—rock doves. One perpendicular cleavage in the cave-roofs was pointed out to me by the boatmen as a favourite haunt of doves, but we failed to dislodge any, and only saw two or three altogether during the day.

"The Maidens" are outstanding pinnacles of rock several hundreds of feet in height, and these are densely covered with cormorants (*Phalacracorax carbo*). This colony of cormorants is also spread over the summit of the cone of Whiten Head and the ledges on its sides up to some 350 feet above the sea. I could easily at that distance see the white thigh-spots, indicating the adult birds in full breeding plumage, with the aid of my binoculars. This is a very large colony of cormorants. A man once climbed up in presence of our boatmen, and brought down a "shawl full of eggs." How he got up has always been a mystery to our boatmen, one of whom is himself a very able rock climber.

A *Peregrine* Falcon was seen near the Head. White-tailed eagles (*Haliaëtus albicilla*) have their eyrie—reported as quite inaccessible—about 3 miles east of Whiten Head. Black guillemots (*Uria grylle*) were not abundant, but several

pairs were seen, and I afterwards picked up a broken egg on Eilean Chlamraig.

Herring gulls—certainly one of the most common and widely spread species of gull on our coasts—was more or less abundant at almost every suitable point of vantage. Rock pipits were omnipresent. Arctic terns were breeding on Eilean Chlamraig and Eilean Hoan, for which two low-lying islands we ran after leaving Whiten Head. Eilean Chlamraig is marked on the new Ordnance Survey map as 50 feet above the sea at its highest point. Eilean Hoan is higher and larger, reaching a height of 83 feet, and being 1 mile in length. These islands are situated near Rispond, a little to the west of the main entrance to Loch Enboll. Eilean Chlamraig is seamed and furrowed by the sea, and is composed of limestone. Both islands hold colonies of terns, herring and lesser black-backed gulls, oyster-catchers, etc. We landed on them, but found few eggs, the great gales, as our men remarked, having destroyed most of them a few days before. After landing again at Rispond, my ghillie, John Sutherland, and I walked over the hill to Loch an't' Sean, and there met for the first time Mr D. Mackay of Portnacon. Thereafter we returned to Durness in the trap, a drive of about 5 miles.

My next tour of inspection of these coast-lines was made to Cape Wrath on the 19th June.

John—my ghillie—and I walked to the ferry, rowed over to the west side of the Kyle, and there met the horse and driver who had come round at low tide by a route over the sands, about 2 miles higher up the Kyle. On the way to Cape Wrath, I fished a loch for a few hours, and then drove on through a desolate country, to Cape Wrath. The view of Cearvig Bay and a bit of the coast at the point where I stopped is very fine, and includes the small but singularly shaped pinnacles of rock which flank the eastern horn of the cliff which encircles the pretty little sandy Cearvig Cove.. The moorland of this district is singularly bare and cold looking, lying at a considerable elevation above the sea, and rolling away inland in wavy undulations, rising into somewhat higher ground about 3 or 4 miles to the southward, the home of the

dunlin and golden plover, and with but few lochs to enliven or brighten up its dreariness. The bold mountain, however, of *Fashbhein* is a redeeming feature, and was ever present to our view as we drove along.

Arriving at the lighthouse, I met Mr Goodsir, the lighthouse-keeper, and had a conversation with him on the subject of the migration of birds at the lighthouse. Few birds appear to strike the light, but vast numbers of solan geese and rock birds are seen passing westward daily and hourly in the autumn, as is more fully recorded in some of our Migration Schedules and Reports. Except a few gulls and a colony of cormorants on the stack—which forms the Cape—there are few birds breeding on the cliffs between Cape Wrath and Cearvig Bay. There is a pair of peregrines close to the lighthouse.

A well, intended to be used by the people at the lighthouse, and having a path formed down the cliff to it, and situated in a "slack" or gully 250 feet at least above the sea, has never been used. It is impregnated with salt, driven up by the great storms to this height, saturating the soil and rock around.

I went to the top of the lighthouse (a revolving red and white light). It is one of the earliest built in Scotland. Some of the reflectors bear the date of 1838.

The view from Cape Wrath towards the south includes Sandwood Bay and the cliffs beyond its entrance, and Bulgie Island, and the high rugged coast between. Inland are the rolling moors and hills already described. To the west and north is the open sea. Lewis is visible in clear weather, but it is only very rarely indeed that the light of the Butt lighthouse can be seen at night, and then only at ebb-tide. It is some 60 miles distant. Rona and Souliskeir are easily and distinctly seen in clear weather, and nearer—within a mile of the Cape and nearly due north, looking almost within stone-cast of the balcony of the lighthouse—lies the dangerous rock of Dhuslag, on which a vessel called the "Captain of Hull" was wrecked. Eastwards is seen Far-out Head, and nearer, Garbh Island and the high cliffs culminating in Clo-More, Cearvig, sands, and shepherd's

house, and some fine, but almost birdless, cliffs between, considerably higher than Cape Wrath.

Drove back to Cearvig, after which, accompanied by John M'Callum, I ascended to the top of Clo-More—a very fine nursery of sea birds. The height of Clo-More, according to survey, is 600 feet. From this point, we looked down upon the comparatively diminutive stacks, which, however, are singularly picturesque ones, and are crowded with sea birds. On one fine broad ledge I counted 100 guillemots, and on another upwards of 60. The puffin, however, keeps up its productive powers here on a *vast* scale, and sustains, as a gregarious species, the character of being the most numerous of all our sea-fowl. The colony extends nearly 3 miles, the area being more or less densely populated in its rubble slopes and cairns, crevices of the rocks and turf summits, throughout its whole height, which averages 450 feet. Razorbills and guillemots are both plentiful on the stacks. I could not make out any bridled guillemots, the distance being too great. Kittiwakes abound at several detached and suitable places towards the east. A pair of peregrines were seen in Clo-Bheag, which is between Clo-More and Cearvig at the entrance to the bay, and soon a single young bird in down was seen in the nest. It appeared through the glasses to be about the size of a puffin, which was sitting not far from it. The nest or eyrie was situated in an apparently inaccessible place, viz., the top of a mound of *débris*, or grass-covered rubble, which rested on a sheer precipice of 150 feet. Above it the rock overhangs, but there is a rent in the cliff, down which it might just be possible for a man to descend with a rope. It will be thus seen that peregrines are fairly numerous on this coast. I have myself seen or heard of four pairs between Cape Wrath and Whiten Head.

The white-tailed eagles bred for many years on the high cliffs east of Clo-More, and between Clo-More and Garbh Island, but in 1879 Mr Colquhoun (author of the "Moor and the Loch") shot one of the old birds. Since then the other bird has been solitary, and has frequently been seen, but has never taken to itself another mate. No doubt these are very old birds. M'Callum once took the eggs at this eyrie, and they

are now in the collection of Mr Allan Scott of Balnakeil, in Leith.

It was quite impossible to estimate, even in the widest manner, the number of puffins in this nursery. They may be spoken of as densely occupying an area of 3 miles, in cliffs 450 feet high.

Next day we went inland, but saw little bird-life—dunlins and golden plover being almost all the birds seen. We visited a lonely loch, from which we vainly tried to allure the heavy trout it is said to contain.

In order to complete my survey of this north coast, I had still to visit Garbh Island; and for this purpose, a fine calm day, with the wind off shore, was chosen, as the journey must be made by boat. Mr Torquil Nicholson, schoolmaster at Durness, accompanied me, and we made a start from Balnakeil Bay about eleven o'clock, with John Sutherland and Hugh M'Leod as boatmen.

Lythe (*Merlangus pollachius*) run to a heavy weight along this coast, and are very powerful. They often run up to 10 or 12 lbs. weight, and are in their first rush stronger than salmon.

We shortly passed the entrance of the Kyle and the Glasslag Rocks, which at high tide form three islands, but are united at low tide. On the outermost and innermost are colonies of herring and lesser black-backed gulls, and a small colony of shags. On the centre island, it appears that a colony of Arctic terns have sole possession; and I saw them buffeting and diving down in mid-air after the gulls, when the latter intruded themselves. The Glasslag Islands are composed of limestone, but a little to the west, on the mainland, gneiss commences, and there is no more limestone — except Garbh Island — between this and Cape Wrath.

Garbh, or The Rough Island, well deserves the name. Its limestone is full of fossils, and I obtained a few, but they are exceedingly difficult to extract, owing to the very hard nature of the rock. Many having been taken away, they are also now more difficult to find.

The nests of the seafowl are much disturbed here. Puffins

used to be plentiful, but their numbers now are quite inappreciable, and they have, for the most part, taken refuge in the lofty *débris* slopes and inaccessible ranges of Clo-More and the coast towards Cearvig Bay.

Eider ducks (*Somateria mollissima*) used to breed sparingly here, as also on the low islands off Loch Eriboll, but I saw nothing of them except at Eilean Hoan, where a fisherman pointed out the site of a last-year's nest.

Kittiwakes (*Larus tridactylus*) frequent the cliffs on the east side of Garbh in considerable numbers, but nests seemed scarce. The rock is much whitened by the birds' excreta, and indeed it has more the appearance of a resting than of a breeding place. They breed, however, on the mainland at several points between Garbh and Cape Wrath.

Herring and lesser black-backed gulls (*L. argentatus* and *L. fuscus*).—The former, which are most abundant, occupy the rough top of the island, but though a number of birds were seen, but few nests were found.

A single black guillemot (*Uria grylle*) flew off the top of the island, but I failed to discover the nesting-place. This species is not numerous on this coast, but occurs all along it in scattered pairs or small colonies.

Rock pipits, equally abundant here as on other parts of the coast.

Guillemots, very few; Razorbills, scarce; Shags, in caves.

The view westwards from Garbh Island embraces Clo-More and its stacks, and the fine range of cliffs and puffin-haunted slopes between Garbh and Clo-More, and beyond to Cape Wrath; and eastwards it extends to Whiten Head, embracing Far-out Head and Balnakeil Bay and House.

The vegetation of Garbh Island is fairly luxuriant, consisting of clumps of sea pink, bladder-campion, scurvy grass (*Cochlearia officinalis*). Of the latter, Mr Mackay informs me, he has gathered leaves at Cape Wrath 3 inches in diameter.

I left Durness on the 22d and went on to Rhiconich, and I completed my ornithological survey of the remaining part of the coast from that point round the west side to Cape Wrath.

I hired a boat and two men from Acriesgill, a small hamlet on Loch Inchard, and sailed out to Bulgie Island, passing through the narrow strait between Rhon Island and the mainland near another fishing hamlet called Oldshore. Loch Inchard is a fine sea loch with splendid harbourage, but narrow, and about 5 miles in length. There is nothing very specially characterising the coast until we arrive nearly opposite the open sandy bay at Loch Sandwood, which is guarded on its southern horn by a fine but short range of cliff, and by the Buachaille or Shepherd, a remarkably fine isolated stack of rock. The Buachaille is about 30 feet square at the base, resting on a solid platform of level under-cliff, washed over by the tide waves, but left bare as each wave recedes. The Buachaille maintains this massiveness—or nearly so—for a height of about 80 feet, and then rapidly diminishes to the top 120 feet higher. The strata are in regular horizontal layers, except on the very summit, which is rough and broken and jagged. As we rowed past within 30 feet of the base we could see a gull sitting on the very highest pinnacle.

Whilst we lay on our oars, admiring this majestic pinnacle, a great thunderstorm burst overhead, accompanied by forked lightning, peals of thunder, and drenching rain, scaring ever and again the sea-birds from their ledges, and adding vastly to the grandeur of the wild scenery. This storm rolled about more or less all day, passing out over the sea towards the Lewis, and crossing the track of a large fleet of fishing boats which were making their way *viâ* the Pentland Firth to the east coast fishery, their contracts at Stornoway having been completed.

On approaching Bulgie Island from the southward, it is seen to consist of one large rounded lump, perhaps 100 feet in height, with six or seven outlying skerries, all more or less covered with sea-birds, either nesting or resting.

Two pairs of greater black-backed gulls (*Larus marinus*) were perched on the topmost pinnacles of the skerries. Cormorants and shags—the former scarce, the latter common —were drying their wings in the light air. Puffins were very

abundant all along the cliff tops and slopes amongst the sea pink tufts, and even occupying crevices in the cliff face. Guillemots were plentiful on the west or seaward side, less so on the landward side, where razorbills took the place of them to a large extent. Herring gulls occupied the grassy top and interior of the island, and kittiwakes in a large colony, but with many immature birds, principally on the north-west and west cliffs, or resting on the skerries. Rock pipits were not abundant.

A curious cave on the north-west side of Bulgie Island is formed by a rent in the rock, which at high tide is filled to the arch or nearly so, and at low water is about 15 feet in height at the entrance. The swell of the Atlantic or its heavier waves rushing into this cave confines the air, in what must be a much larger cavity within, which, being liberated on the gradual backflow of the wave, rushes out with a loud roar, and casts the spray off the wave tops nearly to the height of the cliff above, which at this point is close upon 100 feet. This cave indeed forms, as it were, enormous bellows, and it is said, during certain conditions of the atmosphere, the roar of its voice can be heard by ships a mile or more at sea.

After rowing round the island the boat was backed to the landing-place, a shelf of rock on the east side, and one of the men and myself effected an easy landing. We scrambled over the island. It is larger than it appears from the sea, *i.e.*, there is more pasture than one would suppose, and that apparently is rich and capable of fattening several sheep. Sheep were at one time kept upon it, but there are none now. The remains of one or two sea-birds, with the flesh clean picked from the bones, suggested the periodical visit of the peregrine falcon, but it is said by the men that none of these birds breed on this part of the coast, a statement, however, which I should be inclined to doubt. The next occupied locality to the south known to me is opposite Handa Island, or on Handa itself, where a gentleman of my acquaintance this year obtained the young, with the assistance of the brothers Matheson of Scourie—famous cragsmen whom I have mentioned before in previous communications

The view from Bulgie Island embraces the coast to the south as far as Rhu Stoir, but Handa Island conceals a large portion of the coast of Aardvaar. Handa itself is well seen, and all the nearer coast, except of course the deep fjords or sea lochs of Inchard and Laxford. Nearer still are various skerries and Rhon Island. To the north we see again Cape Wrath and the lighthouse, and the intervening rugged coast-line, including the Buachaille and Loch Sandwood, almost immediately opposite Bulgie Island. The position of Loch Guisgach, the lonely loch of the big trout, which I visited from Cearvig was easily determined, so I may be said to have pretty accurately joined to-day's survey of the coast with that of the days I visited Cape Wrath and Loch Guisgach.

The vegetation of Bulgie Island is somewhat richer and more varied than most similarly situated islands on our British coasts. I gathered besides the bladder campion, sea pink, and sorrel, a coarse camomile and a wild parsley, and also *Cochlearia officinalis* in great luxuriance, besides several others.

Of birds the ordinary rock species were present and fairly abundant, but rock pipits were, curiously enough, rather scarce.

On another occasion I hope to continue my ornithological survey to the east of Whiten Head.

Records of Rarities Exhibited to the Royal Physical Society in 1885.

No. of Record Form.	Date.	Locality and District.	Species.	Age—Ad. or Juv.	Sex	Alone or in Company.	With its own, or other Species.	Comparative Nos.	Flying in which Direction when seen or shot.	If caught or killed at Light, on which side—N., N.E., N.W., S., S.E., or S.W.	Direction of the Wind at the time, Strength, and Weather.	Prevailing Winds for past .. days, past .. weeks.
7.	1885, May 2.	Pentland Skerries. Also at Isle of May on 1st and 2d May.	Pied Flycatcher, *Muscicapa atricapilla* (L.). *Two.*	Ad. ♂ and Ad. ♀	♂ and ♀	In Co.	Own & other.	Great many.	About the Island.	...	S.E. Strong Thick Haze.	Easterly
8.	1885, May 24.	Isle of May.	1 Dotterel, *Eudromias morinellus* (L.).	Ad.	♂	Alone.	Other Species.	Numeous Other Species.	West.	Killed on East side.	N.W. Light Rain.	Variable for some days, but prevailing S.W.
9.	1885. May 2.	Isle of May. "Forth."	Ortolan Bunting, *Emberiza hortulana* (L.). *Two.*	Ad.	♂	.	One other.		...	..	S.E. Light.	Clear. Thick Fog at Night.
10.	1885. May 2.	Isle of May. "Forth."	Red-Backed Shrike, *Lanius collurio* (L.).		♂		.	..	.	..		
11.	1885. Sept. 12.	Isle of May. "Forth."	Wryneck, *Jynx torquilla* (Lin.).			In Co.	With one of its own Species.			.	W.S.W. Approaching a Gale.	W. for two days.

NOTES AND REMARKS.

No. 7.

If along with other species, mention the names of the latter here:—Redstarts, many more of the Pied Flycatchers, Hedge Sparrows. The Head Lightkeeper and two of his assistants chased these birds till the birds were tired, and caught them, and also a fine adult male Common Redstart.

Destination of Specimen.—Possession of Mr John Gilmour, Head-keeper, Pentland Skerries.

Recorded in this Volume (VIII., p. 498) of *Proc. Roy. Phys. Soc.*, 1885.

Footnote.—Remarks may consist of further Field Dissection or Cabinet Notes of Recorder.

Birds sent me for identification, and stuffed by Mr M'Leay of Inverness for Mr Gilmour, 10th May 1885.—*Auct.* J. A. HARVIE-BROWN.

No. 8.

Killed at the Lantern at 0·30 A.M., 24th May 1885.

Isle of May Collection (Temp. Curator, Mr Joseph Agnew).

Recorded in this Volume (VIII., p. 498) of *Proc. Roy. Phys. Soc.* Edinburgh, 1885.—J. A. HARVIE-BROWN.

No. 11.

Unfortunately this specimen wants the tail, still it will be useful in the Isle of May Collection. Mr Evans, during a subsequent visit to the Isle of May, actually picked up some of the feathers of this bird, which have since been restored to the specimen. Another Wryneck was captured at N. Unst Lighthouse on 9th September (see Migration Schedules for 1885).

Destination of Specimen.—Isle of May Collection (J. Agnew, present Curator).

Recorded in this Volume (VIII., p. 498) of *Proc. Roy. Phys. Soc.*, 1885.

JOURNAL OF PROCEEDINGS.

SESSION CXIII.

Wednesday, 21st November 1883.—RAMSAY H. TRAQUAIR, M.D., F.R.S., President, in the Chair.

The following gentlemen were elected as Ordinary Fellows of the Society: Charles Fraser; George Sheriff.

An Opening Address was delivered by Professor ARCHIBALD GEIKIE, LL.D., F.R.S., on "The Origin of Coral Reefs."

Wednesday, 19th December 1883.—Dr TRAQUAIR, F.R.S., President, in the Chair.

The following Office-Bearers were elected:

Presidents—RAMSAY H. TRAQUAIR, M.D., F.R.S.; BENJAMIN N. PEACH, A.R.S.M., F.R.S.E.; JOHN A. HARVIE-BROWN, F.R.S.E., F.Z.S.
Secretary—ROBERT GRAY, V.P.R.S.E. *Assistant-Secretary*—JOHN GIBSON.
Treasurer—CHAS. PRENTICE, C.A., F.R.S.E. *Librarian*—J. T. GRAY, M.A.
Councillors—T. B. Sprague, M.A.(Cantab.), F.R.S.E.; William Evans; Andrew Wilson, L.D.S.; A. C. Stark, M.B.; Patrick Geddes, F.R.S.E.; Frank E. Beddard, M.A.(Oxon.), F.R.S.E.; Johnson Symington, M.B., etc.; Andrew Moffat; John Hunter, F.C.S.; R. Sydney Marsden, D.Sc., F.R.S.E.; Robert Kidston, F.G.S.; A. B. Herbert.

The following gentlemen were elected Ordinary Fellows of the Society: William Gemmell, M.B., C.M.; Alexander Adam; Alexander Black, M.B., C.M., M.R.C.P.E.; Thomas Duddingston Wilson, M.A., M.B., F.R.C.S.E.; David Hepburn, M.B., C.M.; Charles Kennedy, M.B., C.M.; George W. Dickson, M.B., C.M., M.A.; Lieut. R. M. Richardson; John Cowper; David Lindsay, M.B., C.M.; J. Evans Jackson; A. H. W. Clemow, M.B., C.M.; A. W. Hare, M.B., C.M.; Professor J. Cossar Ewart, M.D., F.R.S.E.; Robert Mitchell; John Henderson; A. F. Bowie.

The following gentleman was elected an Honorary Fellow of the Society: Archibald Geikie, LL.D., F.R.SS.L. & E., Director General of the Geological Survey of Great Britain and Ireland.

The following communications were read:

1. "Notes on the genus *Gyracanthus*." By R. H. TRAQUAIR, M.D., F.R.S.
2. "On a Specimen of *Pecopteris* (*? polymorpha*, Brongt.) in Circinate Vernation, with remarks on the genera *Spiropteris* and *Rhizomopteris* of Schimper." By ROBERT KIDSTON, F.G.S.
3. "On a new Species of *Schutzia* from the Calciferous Sandstones of Scotland." By ROBERT KIDSTON, F.G.S.
4. "On the Structure of *Sarcodictyon*." By Professor W. A. HERDMAN, D.Sc., F.R.S.E.

5. "Notes on the Islands of Sula Sgeir or North Barra, and North Rona, with a list of the Birds inhabiting them." (Specimens exhibited.) By JOHN SWINBURNE, Esq.
6. "On the Occurrence of the Little Gull (*Larus minutus*) in the island of North Uist." By JOHN A. HARVIE-BROWN, F.Z.S. (Specimen exhibited.)
7. "Exhibition of a Skeleton of the Moa (*Dinornis didiformis*)." By W. E. HOYLE, M.A.(Oxon.), F.R.S.E., etc.
8. "On the Occurrence of the Osprey (*Pandion haliæetus*) in Midlothian." (Specimen exhibited.) By Dr TRAQUAIR, F R.S.

Wednesday, 16th January 1884.—J. A. HARVIE-BROWN, F.R.S.E., F.Z.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Rev. H. A. Macpherson, M.A.(Oxon.); J. T. Cunningham, B.A.(Oxon.), F.R.S.E.; Robert Young; Alfred Beaumont; George Johnston; Thomas Shaw.

The following communications were read:

1. "Note on Intra-epithelial Capillaries in *Oligochæta*." By F. E. BEDDARD, M.A.(Oxon.), F.R.S.E.
2. "The Geognosy of the Harz Mountains—with exhibition of the Rocks and Metallic Minerals of the region described." By H. MOUBRAY CADELL, B.Sc., H.M. Geological Survey of Scotland.
3. Professor J. COSSAR EWART exhibited with Remarks a Specimen of an Electric Ray (*Torpedo nobiliana*) taken by a trawler near Wick in January 1884.

Wednesday, 20th February 1884. Dr TRAQUAIR, F.R.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: James E. A. Ferguson, Robert Lindsay; Professor J. Geikie, F.R.S., Malcolm Laurie.

The following communications were read:

1. "The Geological Structure and Age of the Harz Mountains." By H. M CADELL, B.Sc.
2. "Remarks on the genus *Megalichthys* (Ag.), with description of a new Species." By Dr TRAQUAIR, F.R S
3. "On the Principles of Classification" By Prof J. COSSAR EWART, M.D.
4. "On the Occurrence of an adult Specimen of Sabine's Gull (*Larus Sabini*) in Scotland," with exhibition of Specimen. By E. BIDWELL, M.B.O U.

Wednesday, 19th March 1884.—B. N. PEACH, F.G S., F.R.S.E., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: Johnston Stephen.

The following communications were read:

1. "Notes on a second Collection of Birds and Eggs from Central Uruguay," with exhibition of Specimens. By J. J. DALGLEISH, M.B.O.U.

2. "Revised List of British *Ophiuroidea.*" By W. E. HOYLE, M.A., F.R.S.E.
3. "The Scottish Metal Mines—the Breadalbane Mines." By J. S. GRANT WILSON, and H. M. CADELL, B.Sc.
4. "Description of easy Method of Stocking Herring Spawning Beds." By Professor J. COSSAR EWART, M.D.
5. Exhibition of Marine Zoological Specimens: (1.) Albino Haddock (*Gadus Æglifinus*). (2.) The Great Forked Beard (*Phycis blennioides*) from Stonehaven. (3.) Tadpole Fish (*Raniceps trifurcatus*) from S. Queensferry. (4.) Power Cod (*Gadus minutus*) from Eyemouth. Professor EWART also exhibited the Spawn of the Herring in various stages of development attached to stones and zoophytes dredged off Ballantrae, some of the young being already hatched.

Wednesday, 23d April 1884.—Dr TRAQUAIR, F.R.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Martin White; John C. Oliphant; J. C. Wright; M. J. Petty.

The following communications were read:

1. "On Boulder Glaciation and Striated Pavements." By HUGH MILLER, F.G.S.
2. "On Scottish Fossil Cycadaceous Leaves, contained in the Hugh Miller Collection, Museum of Science and Art." By J. T. RICHARDS. (Communicated by Dr Traquair.)
3. "List of Shells and Zoophytes from the Firth of Forth," not hitherto recorded in the Society's *Proceedings.* By JOHN R. HENDERSON.
4. Exhibition of Specimens illustrative of the Silver Districts of Colorado (Leadville and San Juan), collected by Mr H. GUNN, A.R.S.M. (Communicated by Andrew Taylor.)
5. The SECRETARY exhibited a Specimen of the Calandra Lark (*Alauda Calandra*) from the neighbourhood of Madrid, showing a peculiar malformation of both mandibles.
6. Exhibition of a Specimen of the Black Redstart (*Ruticilla titys*, Scop.), taken last month on the Pentland Skerries, Pentland Firth. By JOHN A. HARVIE-BROWN, F.R.S.E.
7. The SECRETARY reported the Occurrence of the Stockdove (*Columba œnas*) in Roxburghshire, a Specimen having been taken during the present month in a rabbit trap by Mr Telfer, Eckford, in that county. The bird was a female, and was examined and identified by Mr James Watson, Jedburgh, who sent a communication to Mr Gray on the subject.

SESSION CXIV.

Wednesday, 19th November 1884.—Dr TRAQUAIR, F.R.S., President, in the Chair.

The following gentleman was elected an Ordinary Fellow of the Society: T. F. Robertson Carr.

An Opening Address was delivered by Dr Traquair, F.R.S., on "Biological Nomenclature."

The following birds were exhibited by the Secretary on behalf of Mr J. A. Harvie-Brown:—(1.) Black Redstart (male) (*Ruticilla titys*, Scop.), which was shot on the Isle of May, 24th October, by Mr J. Agnew; (2.) Leach's Petrel (*Thalasidroma Leachii*), which was taken on the Lighthouse at Girdleness, Aberdeenshire, during the past month.

Wednesday, 17th December 1884.—B. N. PEACH, F.G.S., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: A. Milne-Murray, M.A., M.B.; Laurence H. Wight, M.A.; A. D. Webster, M.D.; Rev. J. Kerr Campbell; Charles E. S. Chambers; Edwin Baily, M.B., C.M.; C. Heron Watson; J. A. Armitage, B.A.; W. Sawers Scott; Rev. A. B. Morris; Jerrold H. Fenton; George Barrow; John Rattray, M.A., B.Sc.; Henry B. Baildon, B.A.(Cantab.); H. H. Gunn, A.R.S.M.; Lionel Hinxman; William Watson, M.D.; H. H. Howell; J. K. Brown.

The following Office-bearers were elected:

Presidents—B. N. PEACH, F.G.S., F.R.S.E.; J. A. HARVIE-BROWN, F.R.S.E., F.Z.S.; Professor JOHN DUNS, D.D., F.R.S.E.

Secretary—ROBERT GRAY, V.P.R.S.E. *Assistant-Secretary*—JOHN GIBSON.

Treasurer—CHARLES PRENTICE, C.A., F.R.S.E. *Librarian*—R. SYDNEY MARSDEN, D.Sc., F.R.S.E., F.C.S.

Councillors—Patrick Geddes, F.R.S.E.; Frank E. Beddard, M.A.(Oxon.); Johnson Symington, M.B., C.M.; Andrew Moffat; John Hunter, F.C.S.; Robert Kidston, F.G.S.; A. B. Herbert; W. E. Hoyle, M.A., M.R.C.S.; Professor J. Geikie, LL.D., F.R.S.; Professor J. Cossar Ewart, M.D.; G. Sims Woodhead, M.D., F.R.C.P.Ed.; Hugh Miller, F.R.S.E.

The following communications were read:

1. "On *Loligopsis* and some other Genera." By WM. E. HOYLE, M.A., M.R.C.S. Mr HOYLE also exhibited a Specimen of *Strongylus contortus* (Rud.).
2. "Method of Consolidating and Preparing Thin Sections of Friable and Decomposed Rocks, Sands, Clays, Oozes, and other Granulated Substances," with exhibition of Specimens. By FRED. G. PEARCEY.
3. "Recent Additions to the Invertebrate Fauna of the Firth of Forth," with exhibition of Specimens. By JOHN R. HENDERSON, M.B.
4. "Note on the Breeding of the Marsh Tit (*Parus palustris*) in Stirlingshire during 1884," with exhibition of nest and eggs. By WM. EVANS, F.R.S.E.
5. "On Abnormal Dentition in a Dingo (*Canis dingo*)," with exhibition of Specimen. By ANDREW WILSON, L.D.S.
6. Mr A. GRAY exhibited living Specimens of the Water Spider (*Argyroneta aquatica*) from Luffness Marshes, Haddingtonshire.

Wednesday, 21st January 1885.—J. A. HARVIE-BROWN, F.R.S.E., F.Z.S., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: James Monteath; Wm. C. Mackenzie; J. Henry Zepero, L.R.C.P. & S.;

Arthur C. Younan, M.B., C.M.; Ernest F. Cox, L.D.S.; W. Owen Williams, M.R.C.V.S.

The following gentlemen were elected Corresponding Fellows of the Society: Professor A. E. Nathorst, Stockholm; Professor Gustav Lindström, Stockholm.

The following communications were read:

1. "Remarks on the Ovary of *Echidna.*" By FRANK E. BEDDARD, M.A., F.R.S.E., F.Z.S.
2. "Investigations on the Movements and Food of the Herring, with additions to the Fauna of the Shetland Islands." By FRED. G. PEARCEY.
3. "Notes on the Birds of the Island of Eigg." By WM. EVANS, F.R.S.E.
4. Exhibition, with Remarks, of Impressions of Raindrops, Recent and Fossil. By ROBERT KIDSTON, F.G.S.
5. Exhibition, with Remarks, of a Specimen of *Larus Kumlieni* from Cumberland Inlet; also of *Larus Sabini* and other Species of Arctic Gulls. By J. A. HARVIE-BROWN, F.R.S.E., F.Z.S. Mr Harvie-Brown also exhibited a specimen of the Little Gull (*Larus minutus*), shot on 17th December at Kincardine-on-Forth, and a Specimen of Forked-tailed Petrel (*Thal. Leachii*) from the Isle of May, shot on 15th August 1884.

Wednesday, 18th February 1885. Professor J. DUNS, D.D., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: George Brook, F.L.S.; Percy M. Turnbull; W. Ivison Macadam, F.C.S.

The following communications were read:

1. "On Fossil Bones of Mammals obtained during Excavations at Silloth." By Professor W. TURNER, M.B., F.R.S.
2. "On some Modifications of Recording Apparatus for Physiological Purposes." By R. MILNE MURRAY, M.A., M.B.
3. "On a New Fossil Fish—*Elonichthys multistriatus* (Traq.), from the Blackband Ironstone of Gilmerton." By Dr TRAQUAIR, F.R.S.
4. "The Aeration of Marine Aquaria." By GEORGE BROOK, F.L.S.
5. "On a New Modification of Lunge's Nitrometer." By JOHN HUNTER, F.C.S.

Wednesday, 18th March 1885.—B. N. PEACH, F.G.S., F.R.S.E., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Harold Raeburn; J. Macdonald Brown, M.B., C.M.; Sidney E. Greg; W. H. Barrett, M.B., C.M.

The following communications were read:

1. "On certain Peat and Tarn Deposits in the North of England." By HUGH MILLER, F.G.S.
2. "On some New or little known Fossil Lycopods (Carboniferous)." By ROBERT KIDSTON, F.G.S.
3. "On the Chemical Composition of some Samples of Scotch Ensilage." By W. IVISON MACADAM, F.C.S., etc.
4. "Caseous Tumours found in the Muscles of the Hake." By G. SIMS WOODHEAD, M.D., F.R.C.P.Ed.

Wednesday, 15th April 1885.—Professor J. DUNS, D.D., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: Alfred C. Wilson; Rev. James M'Naught.

The following communications were read:

1. "On Reproduction of Lost Parts and Abnormality." By Professor J. DUNS, D.D.
2. "Notes on Contorted Shales below the Till in Craigleith Quarry," etc. By H. M. CADELL, B.Sc.
3. "Notes on the Structure of a New Species of Earthworm belonging to the genus *Acanthodrilus* (E. P.)." By FRANK E. BEDDARD, M.A., F.Z.S.
4. "Notes on the Presence of certain Diatoms in a Town Water Supply." By W. IVISON MACADAM, F.C.S., etc.

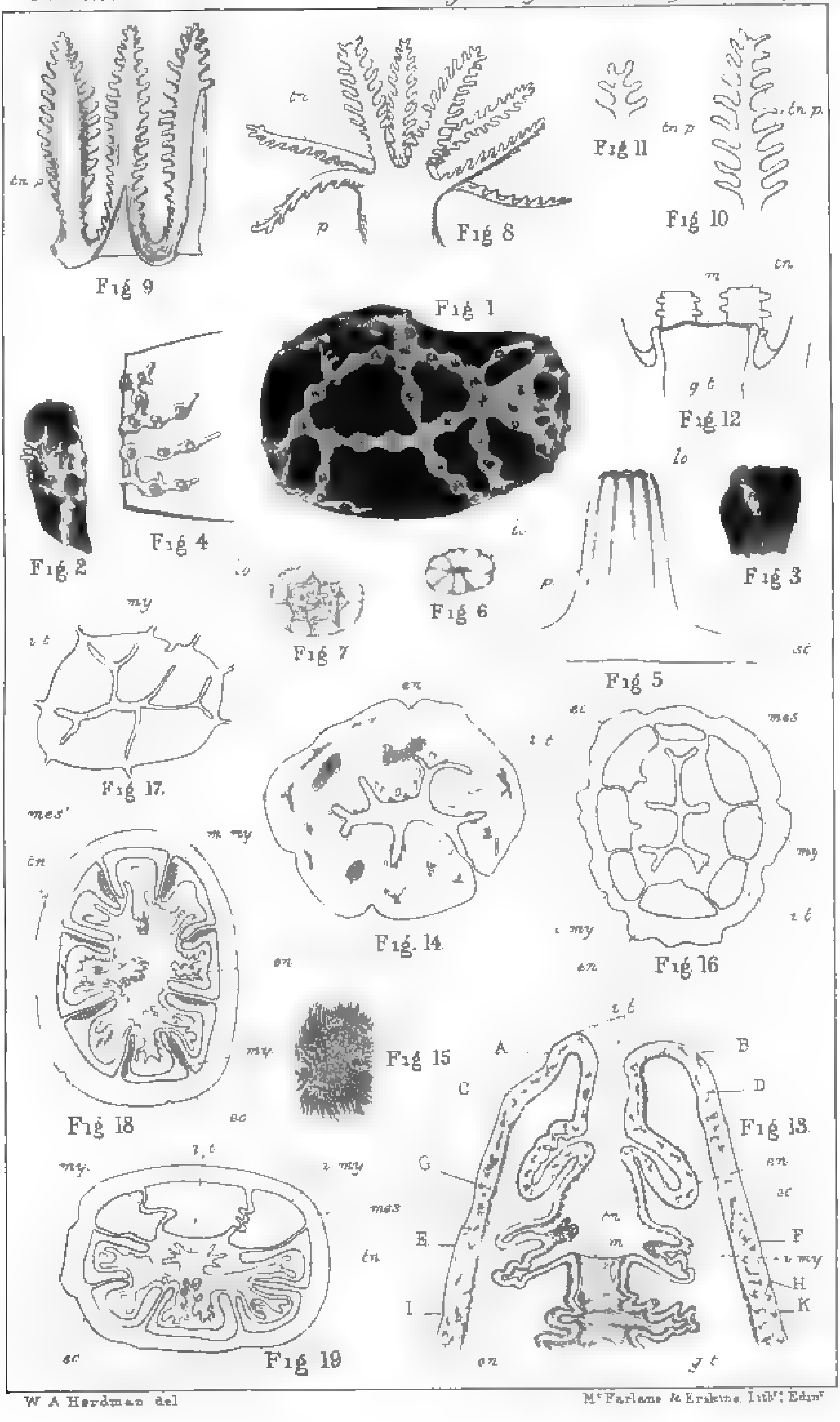
Wednesday, 20th May 1885.—Professor J. DUNS, D.D., President, in the Chair.

The following gentlemen were elected Ordinary Fellows of the Society: T. E. Buckley, B.A., F.Z.S.; Robert F. Burt; John Macgregor, L.R.C.P. and S.

The following communications were read:

1. "On New Selachian Remains from the Calciferous Sandstone Series." By Dr TRAQUAIR, F.R.S.
2. (1.) "Observations on Living Cephalopoda." (2.) "Note on *Loligo Forbesii*, Steenst." By W. E. HOYLE, M.A.
3. "Caseous Ulcer in Skin of Cod." By G. SIMS WOODHEAD, M.D., F.R.C.P.Ed.
4. "Note on the Paired Dorsal Vessel of certain Earthworms." By F. E. BEDDARD, M.A., F.Z.S.
5. "The North-West Coasts of Sutherland and their Bird Life." By J. A. HARVIE-BROWN, F.R.S.E., F.Z.S.
6. "Note on the Contents of Two Bits of Clay from the Elephant Bed at Kilmaurs in 1817." By JAMES BENNIE, H.M. Geological Survey.
7. The SECRETARY exhibited, on behalf of Mr J. A. HARVIE-BROWN, the following birds: (1.) Ortolan Bunting (*Emberiza hortulana*), two specimens, both males, killed 2d and 5th May 1885. (2.) Red-Backed Shrike (*Lanius collurio* ♂, shot 5th May. (3.) Pied Flycatcher (*Muscicapa luctuosa*), ♂, shot 1st May 1885. (4.) Rough (*Machetes pugnax*), shot 1st May 1885. All from the Isle of May, and captured by Mr Agnew, Lighthouse Keeper there.

PLATE I.



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SARCODICTYON CATENATA

Vol. VIII Royal Physical Society, Edinburgh

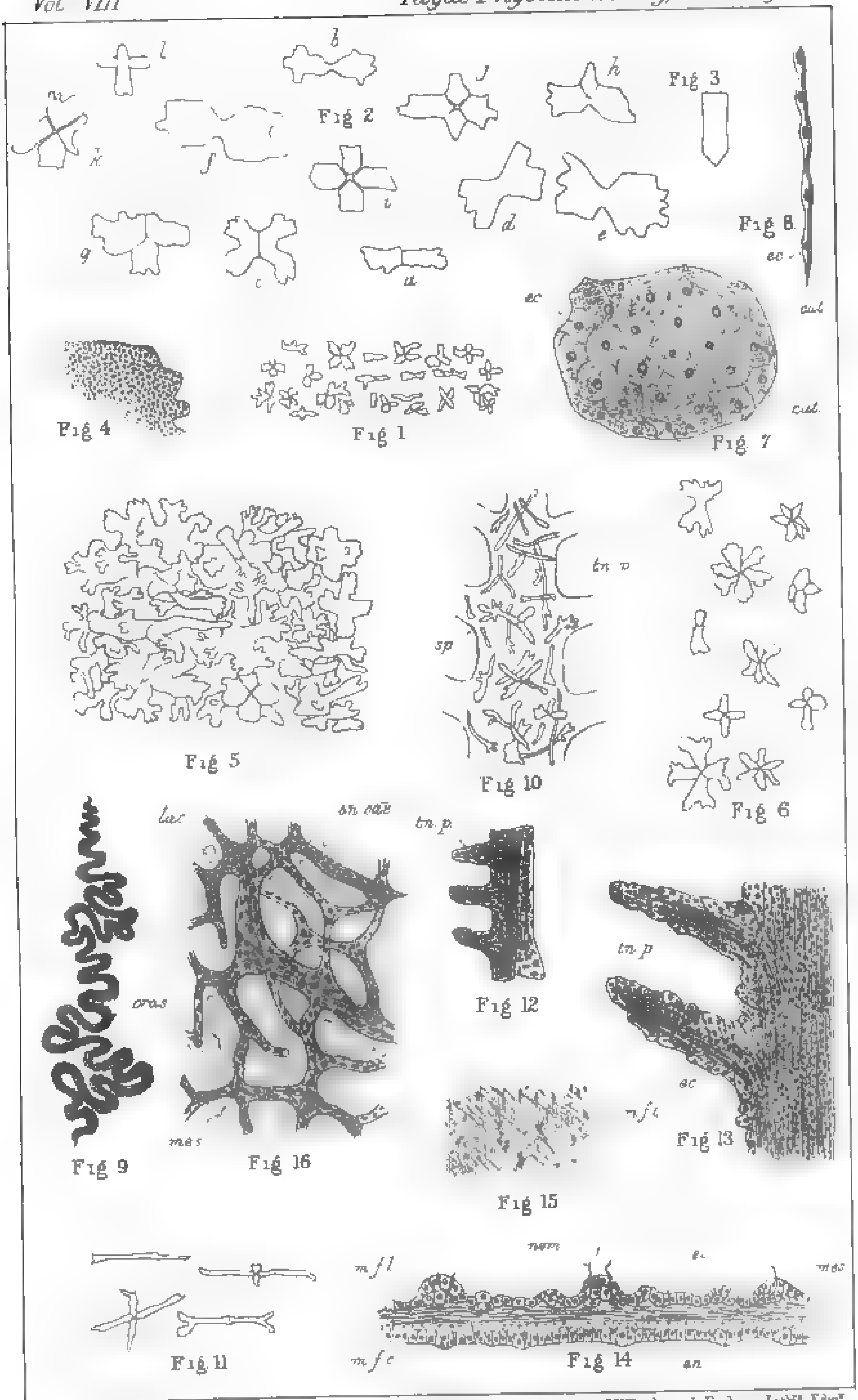

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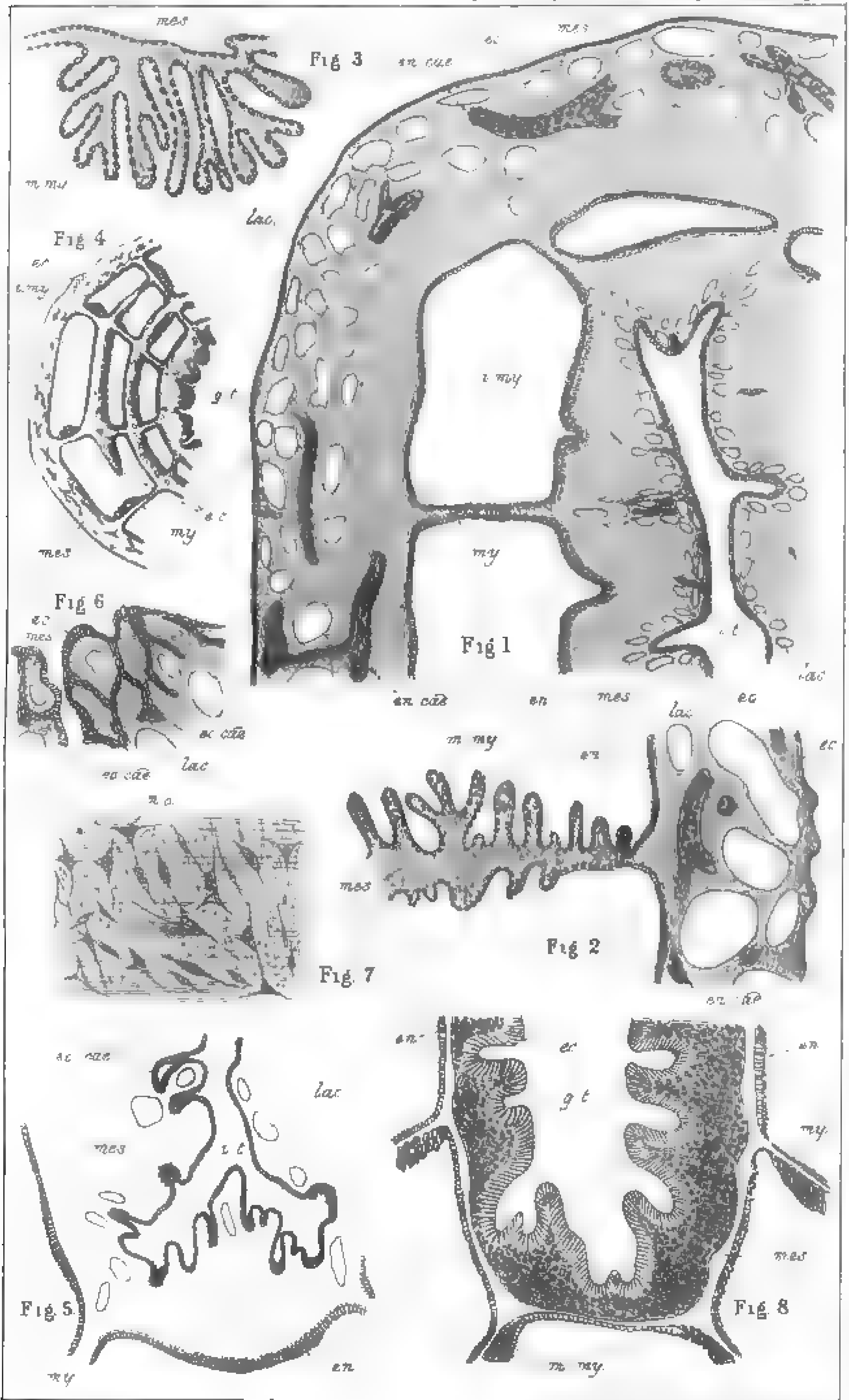
PLATE III

Vol VIII Royal Physical Society, Edinburgh



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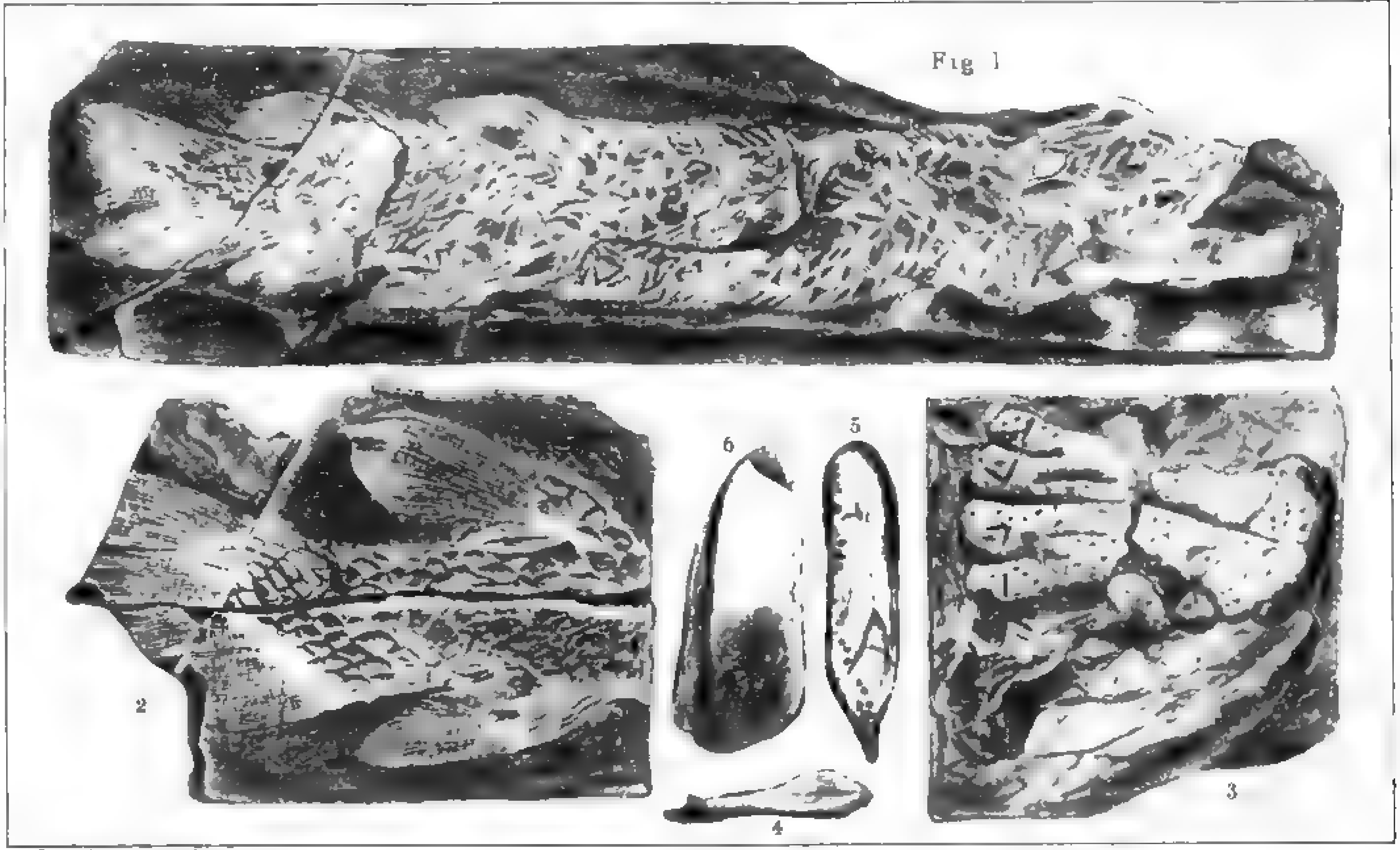
SARCODICTYON CATENATA

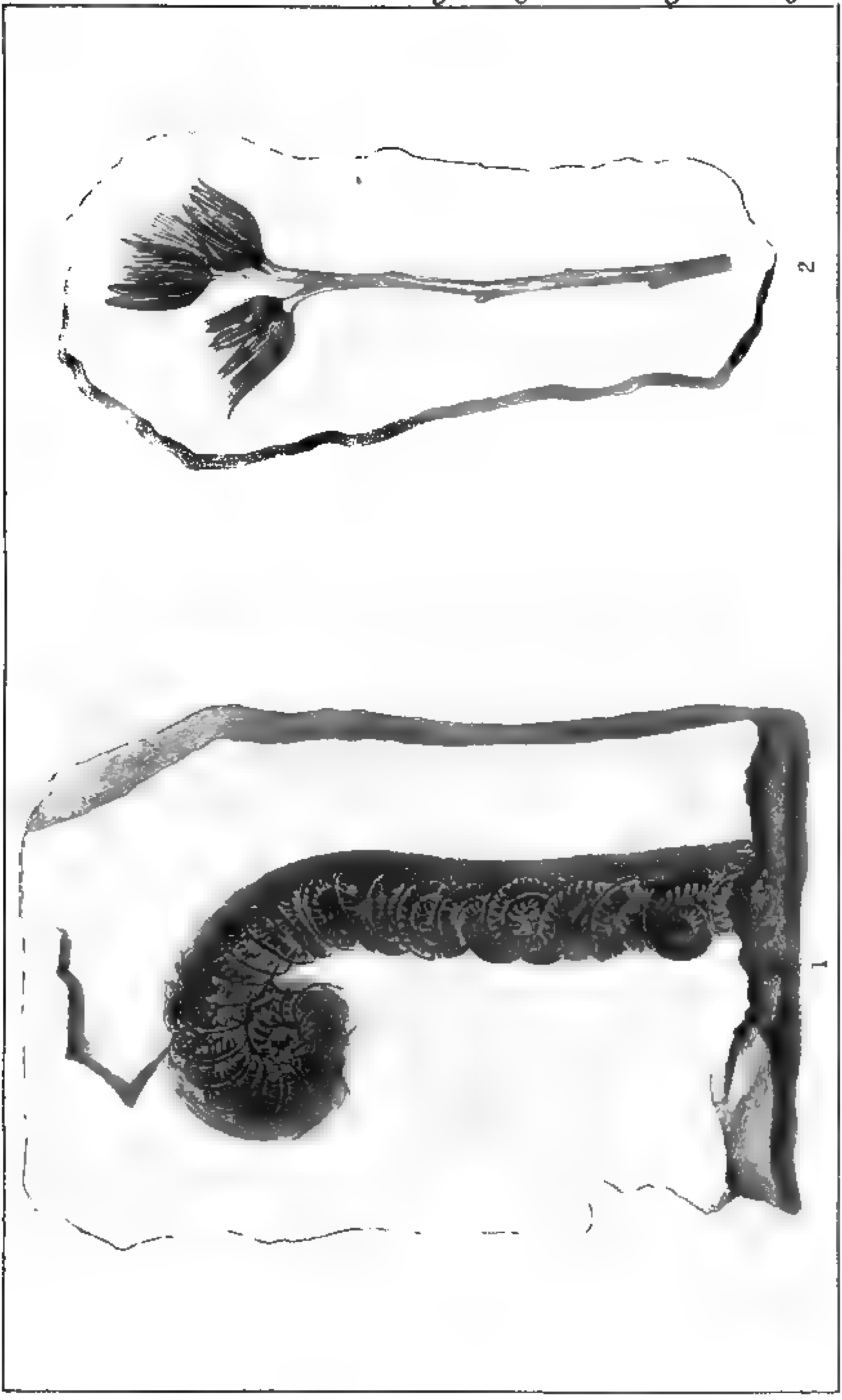
PLATE IV



R H Traquair del.

Megalichthys laticeps *Traquair*

PLATE V.



Robt Kidston del

1 SPIROPTERIS (PECOPTERIS POLYMORPHA *Bgt*) 2. SCHUTZIA BENNIEANA *Kidst*

McFarlane & Erskine, Lith. Edin.

BOULDER TRAINS AND PAVEMENTS.
FILLY SIDE, PORTOBELLO, NEAR EDINBURGH.

PLATE VII.

Vol VIII *Royal Physical Society, Edinburgh*

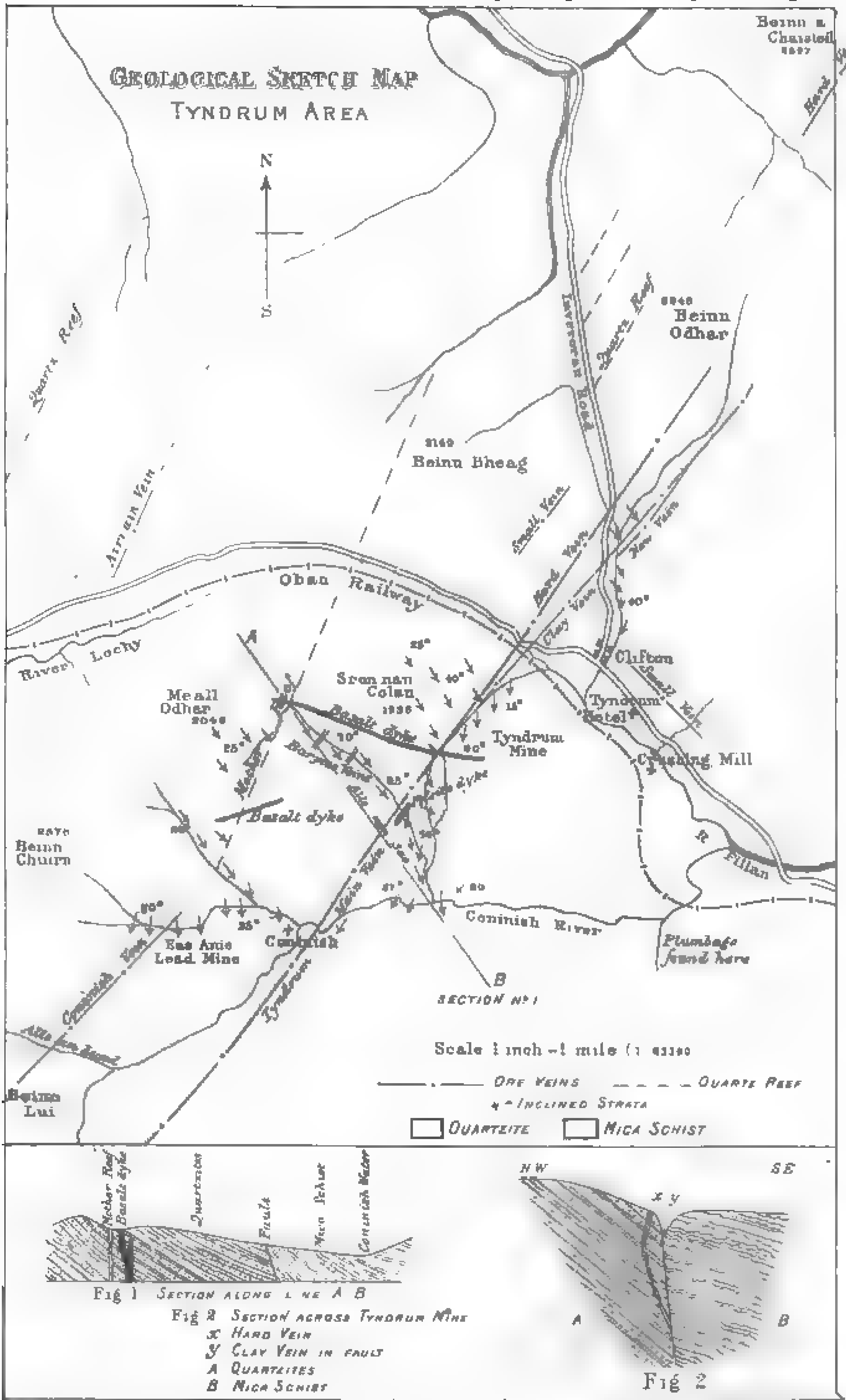


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Plate VIII.

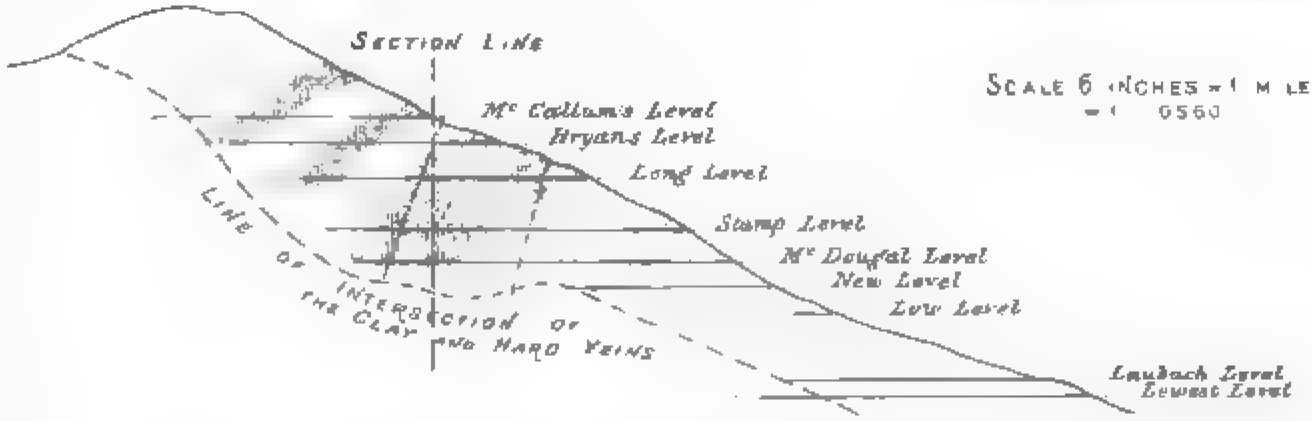
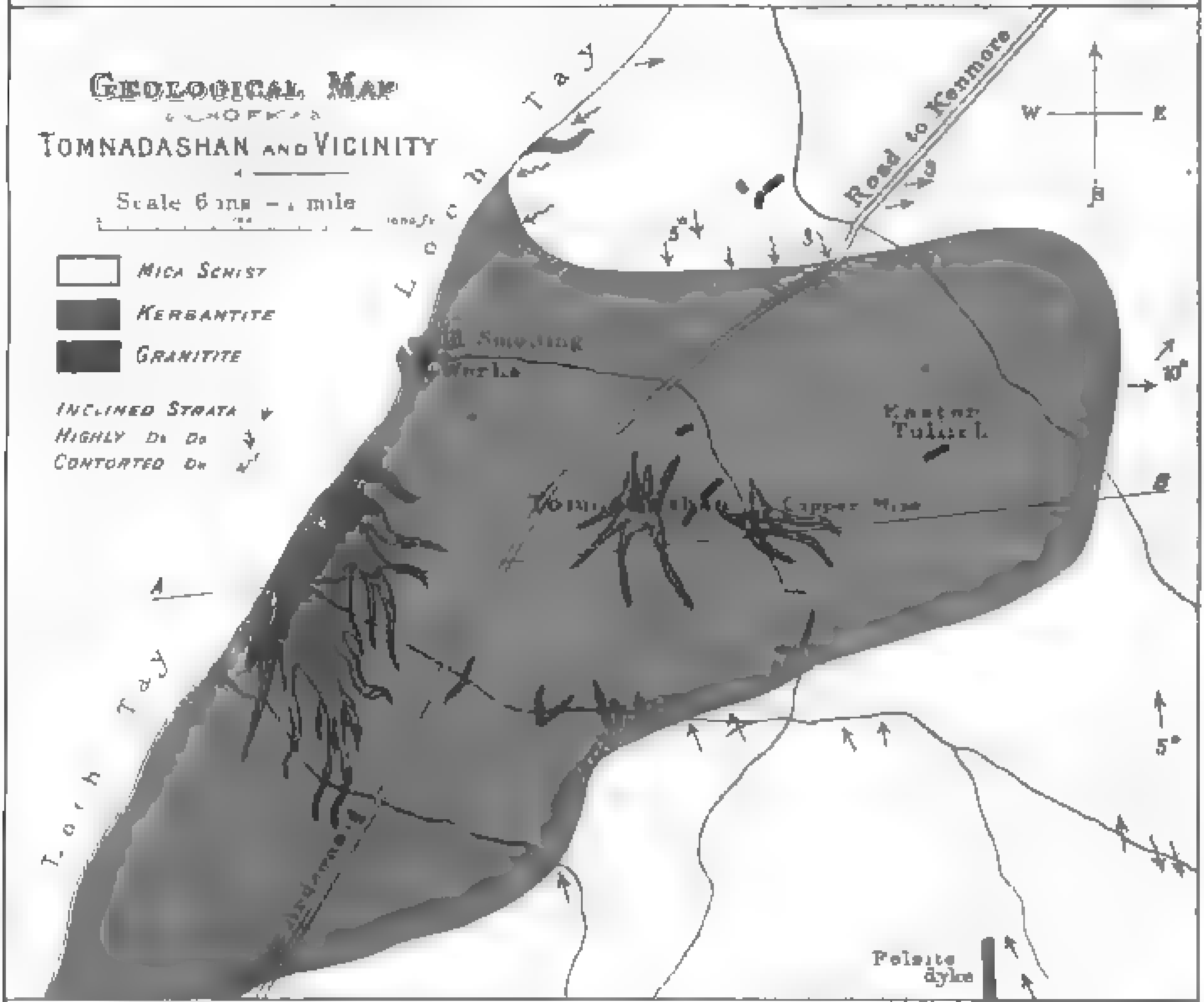


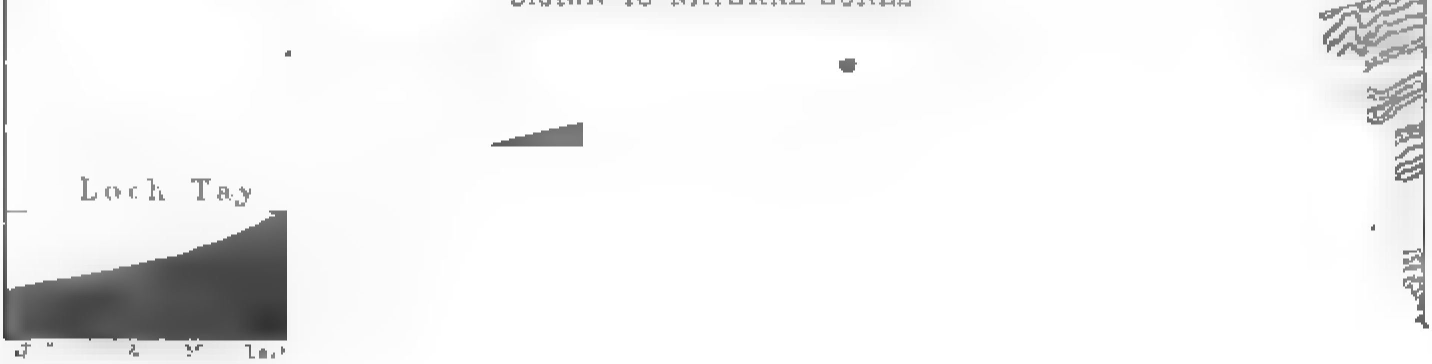
Fig 3 Tyndrum Mines

Sketch Section showing distribution of Ore in "Hard Vein"

Ore richest over shaded portions



Section along line A B
drawn to natural scale



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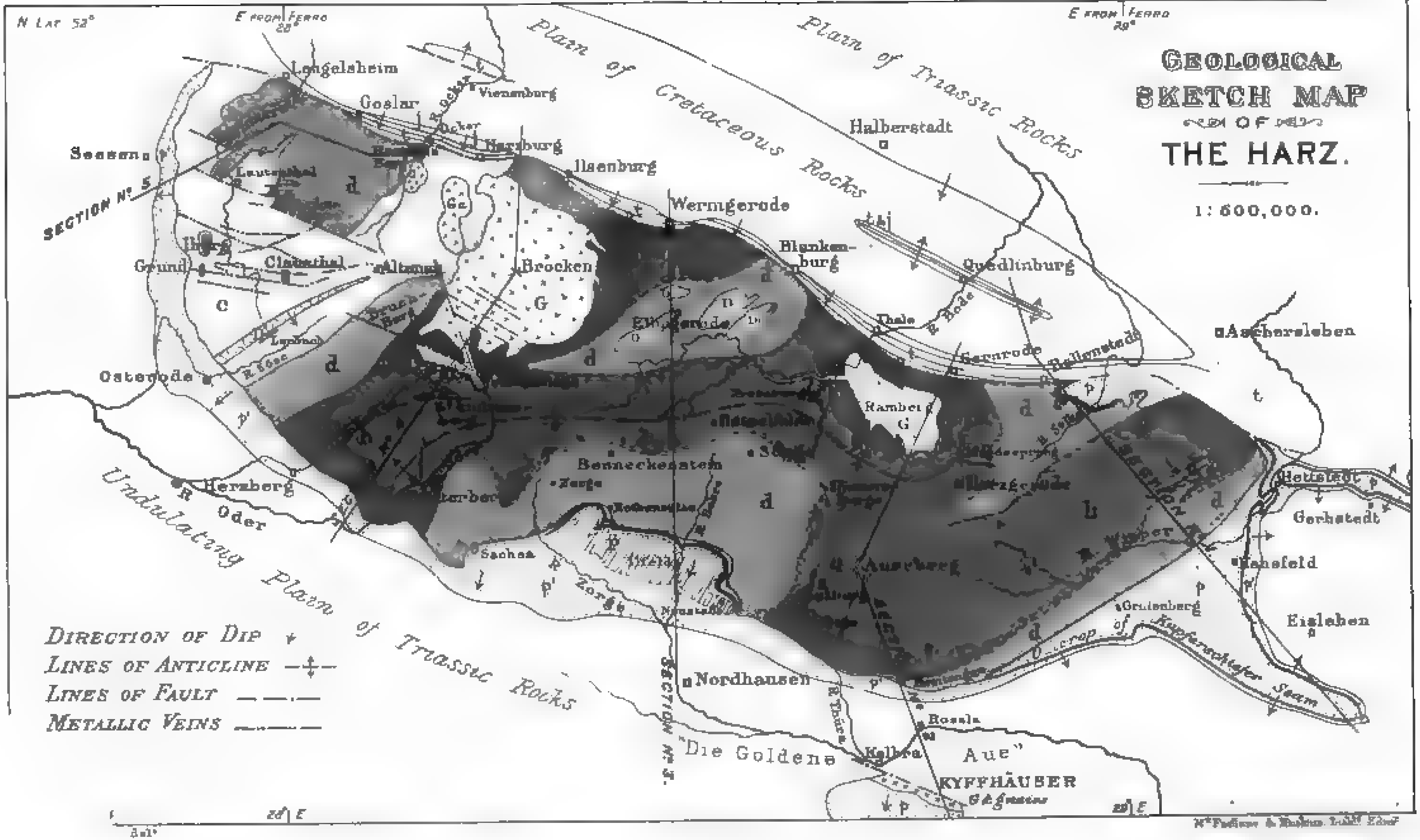

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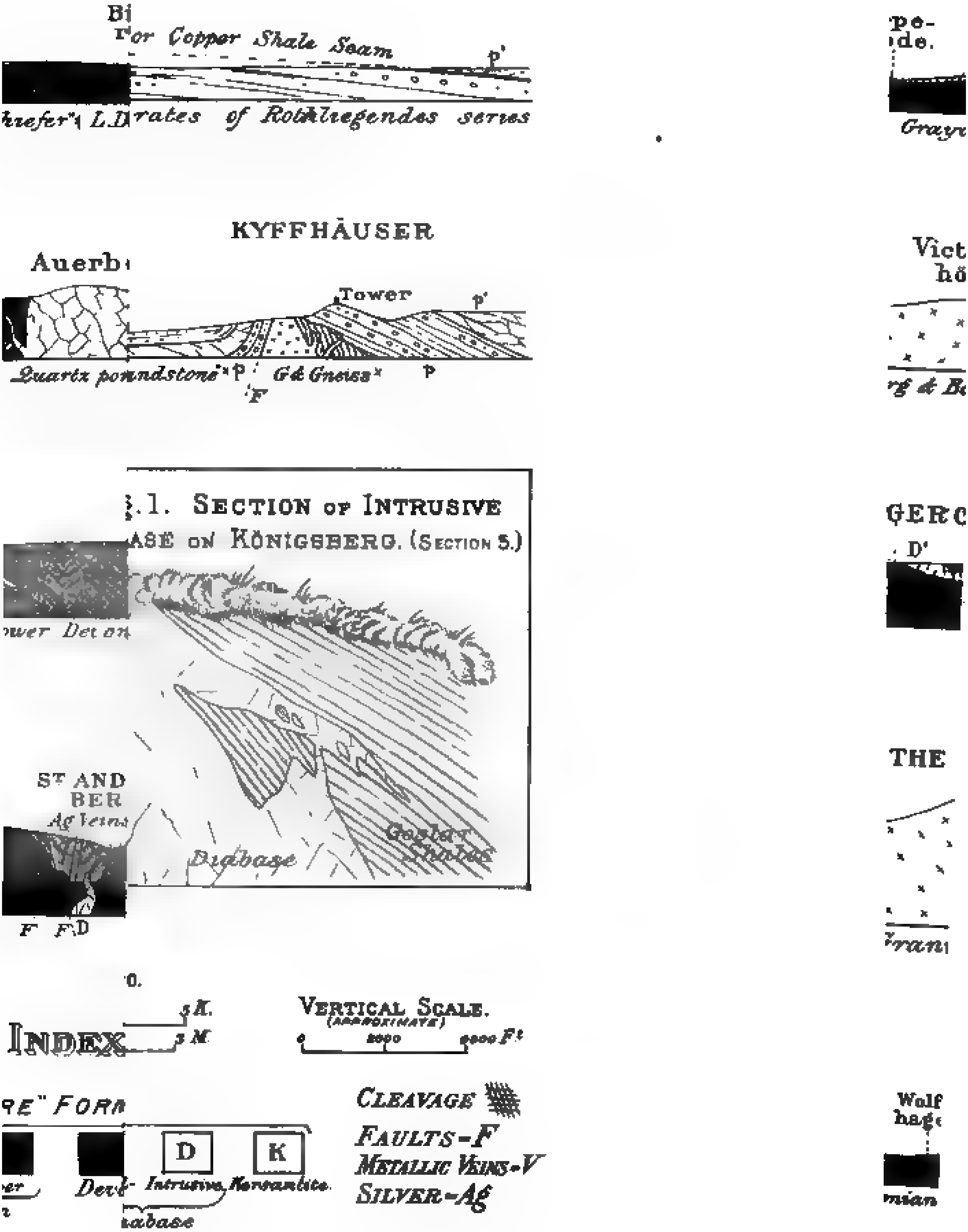

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Vol. VIII.

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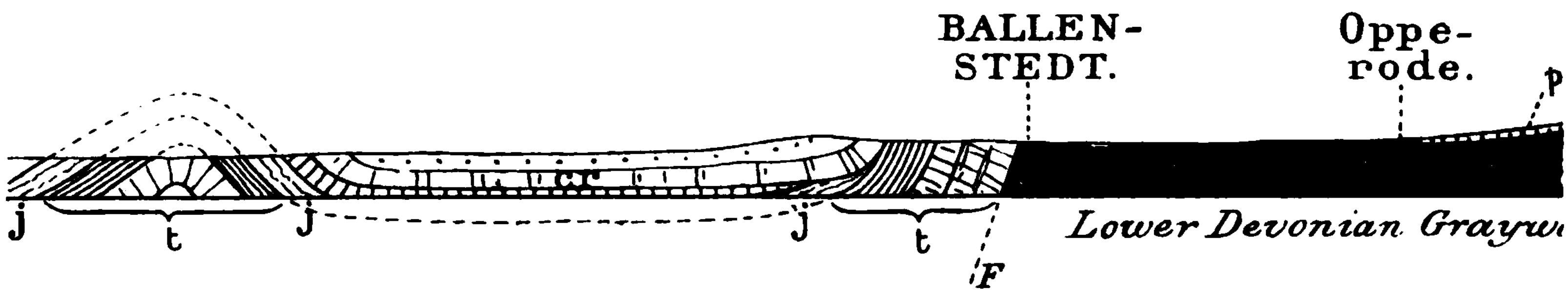

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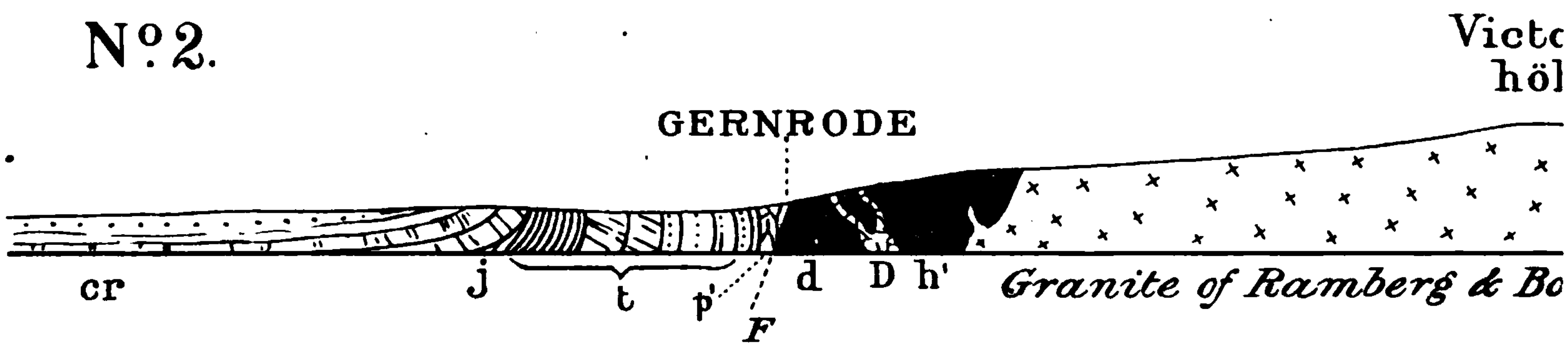

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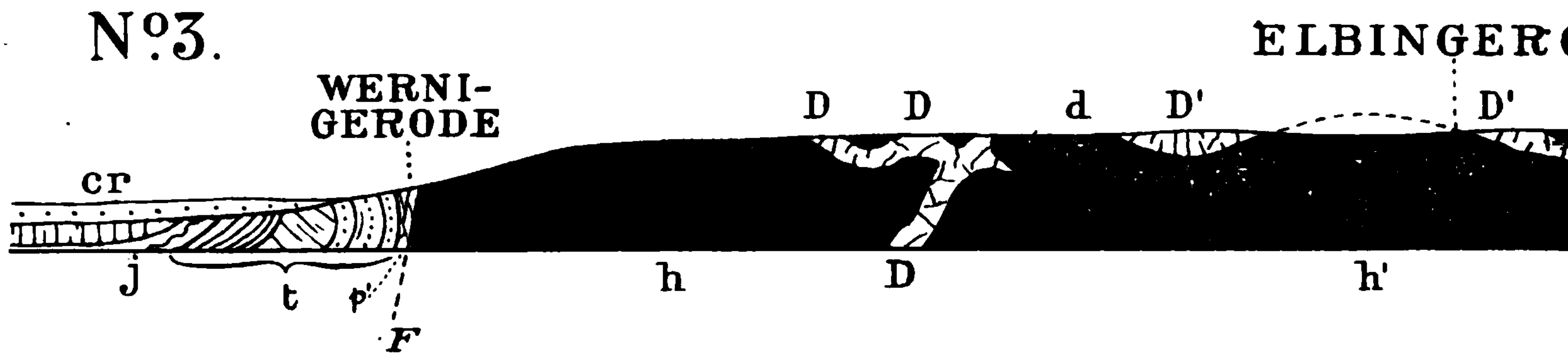

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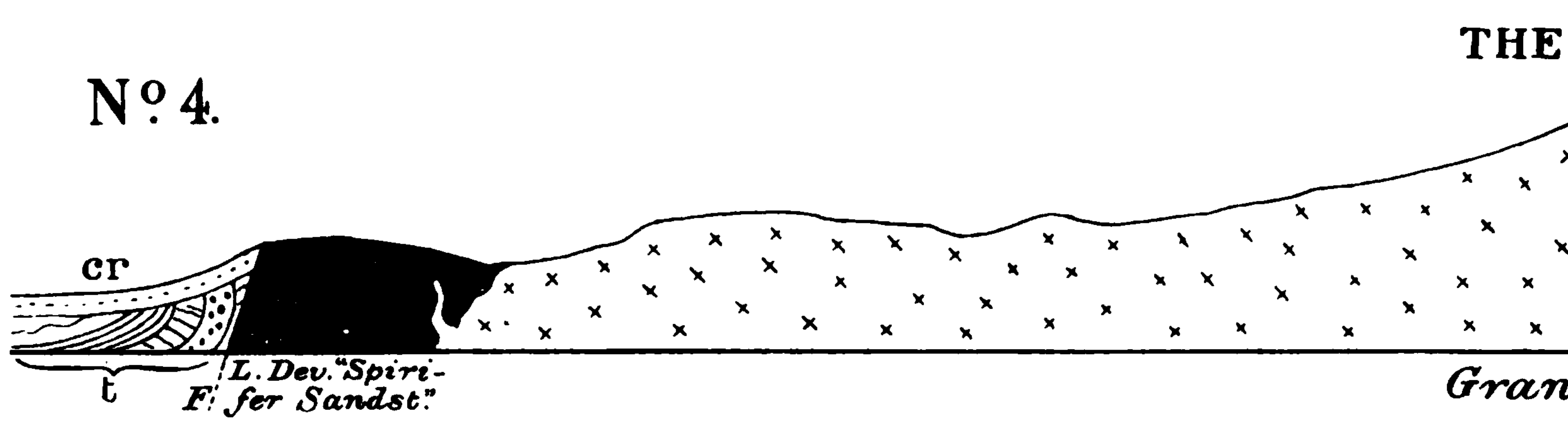

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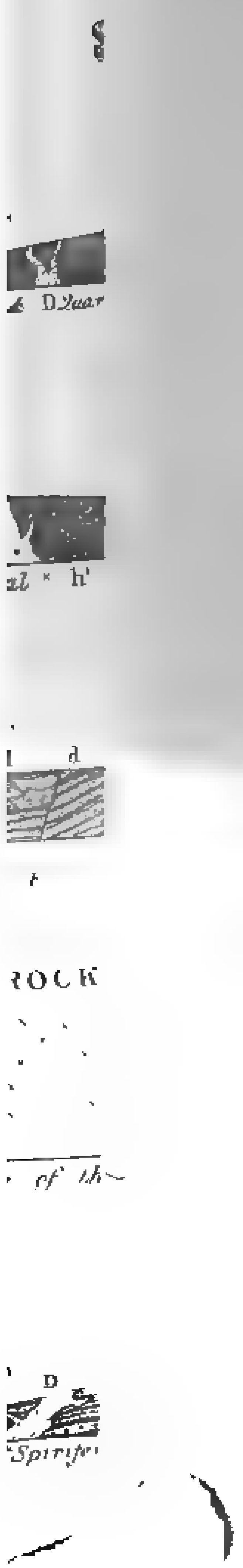

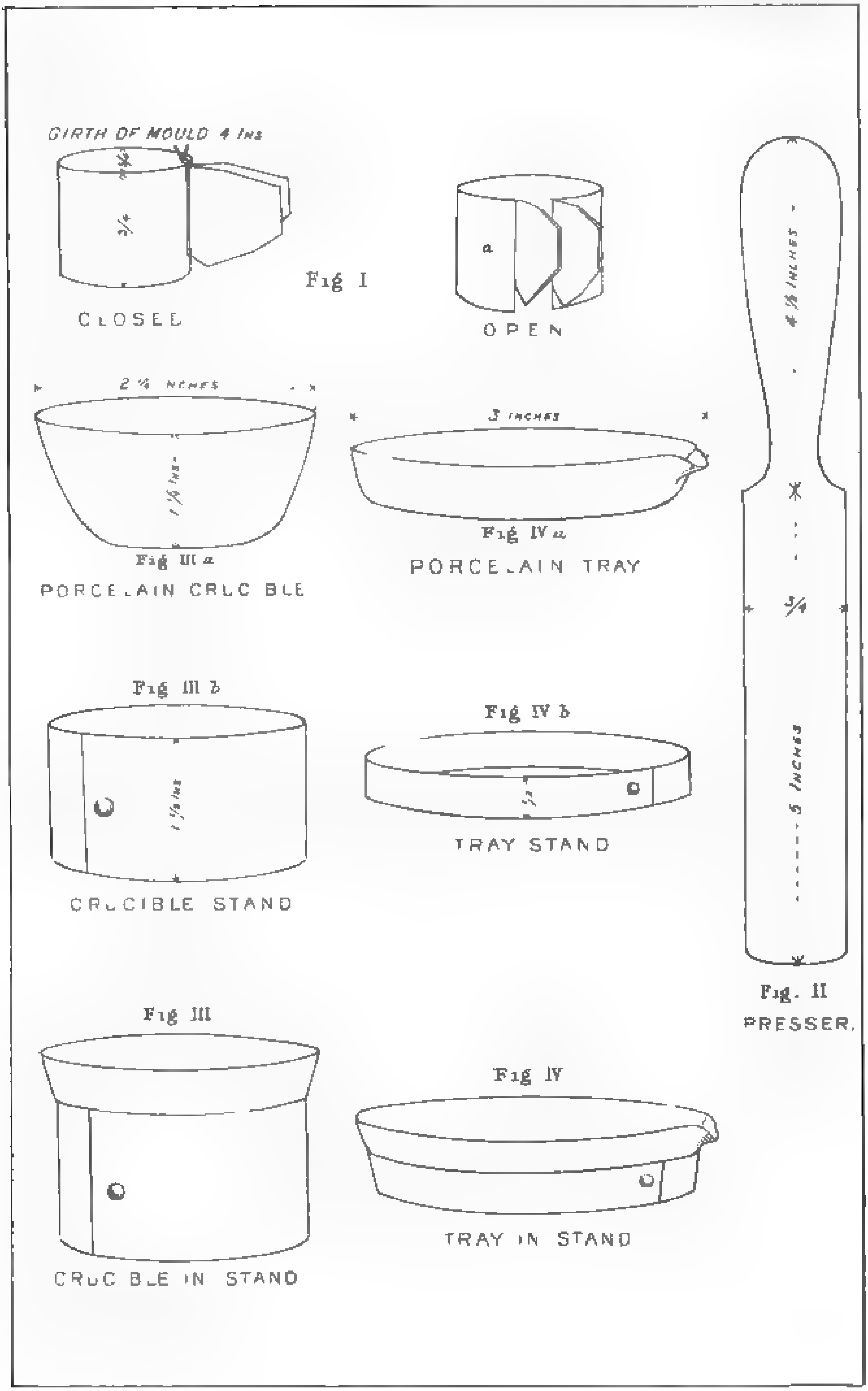

F. G. Pearcey del. McFarlane & Erskine Lith. Edin.

Vol. VIII.   Royal Physical Society, Edinburgh

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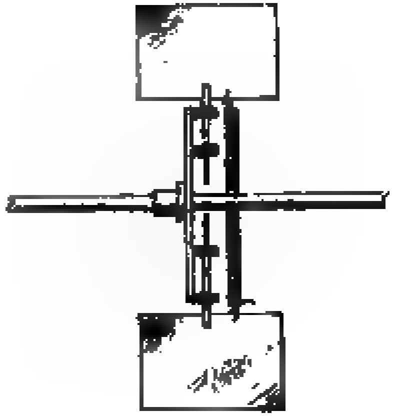

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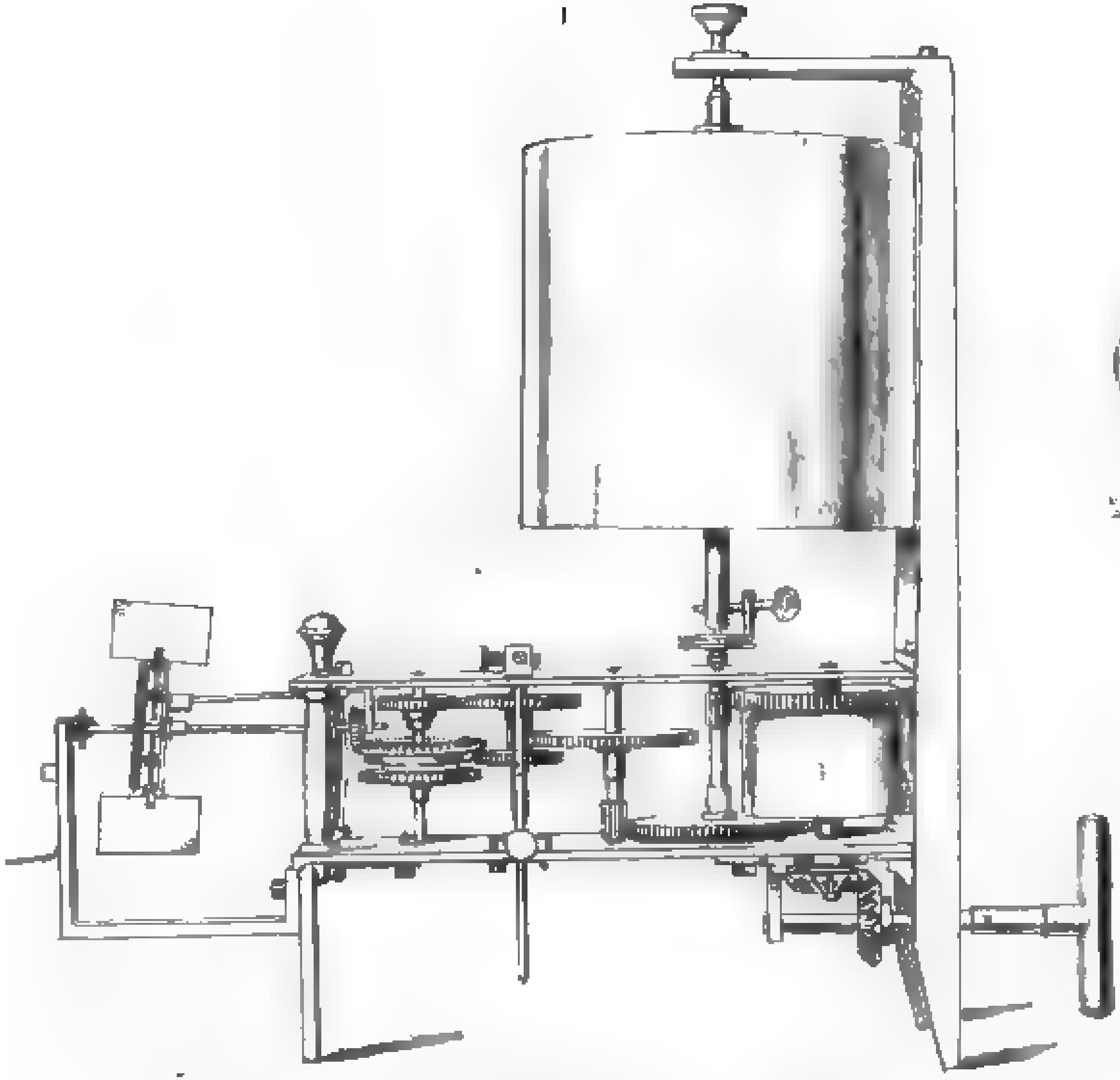

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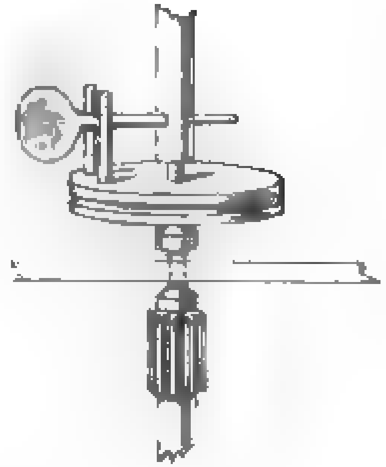

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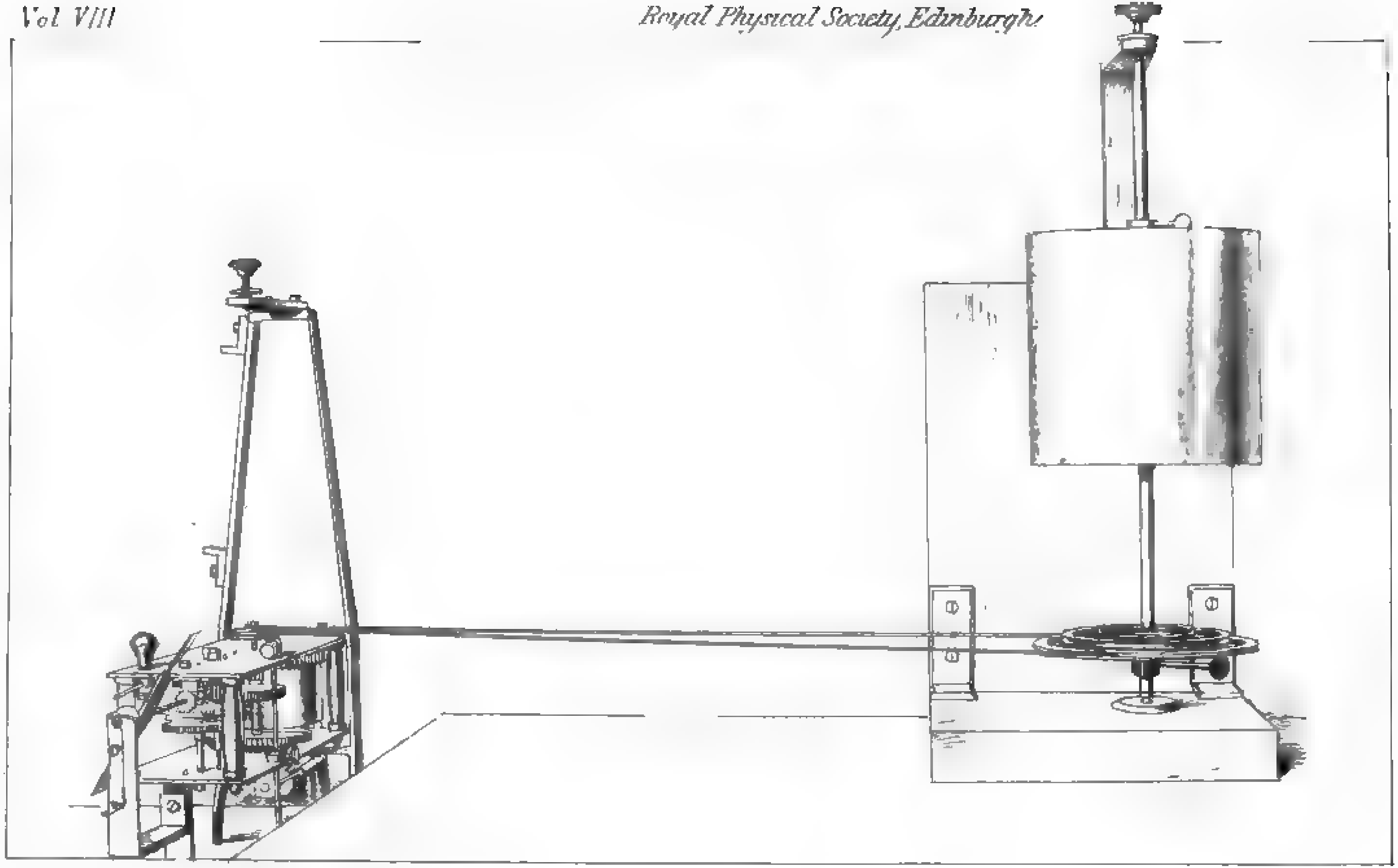

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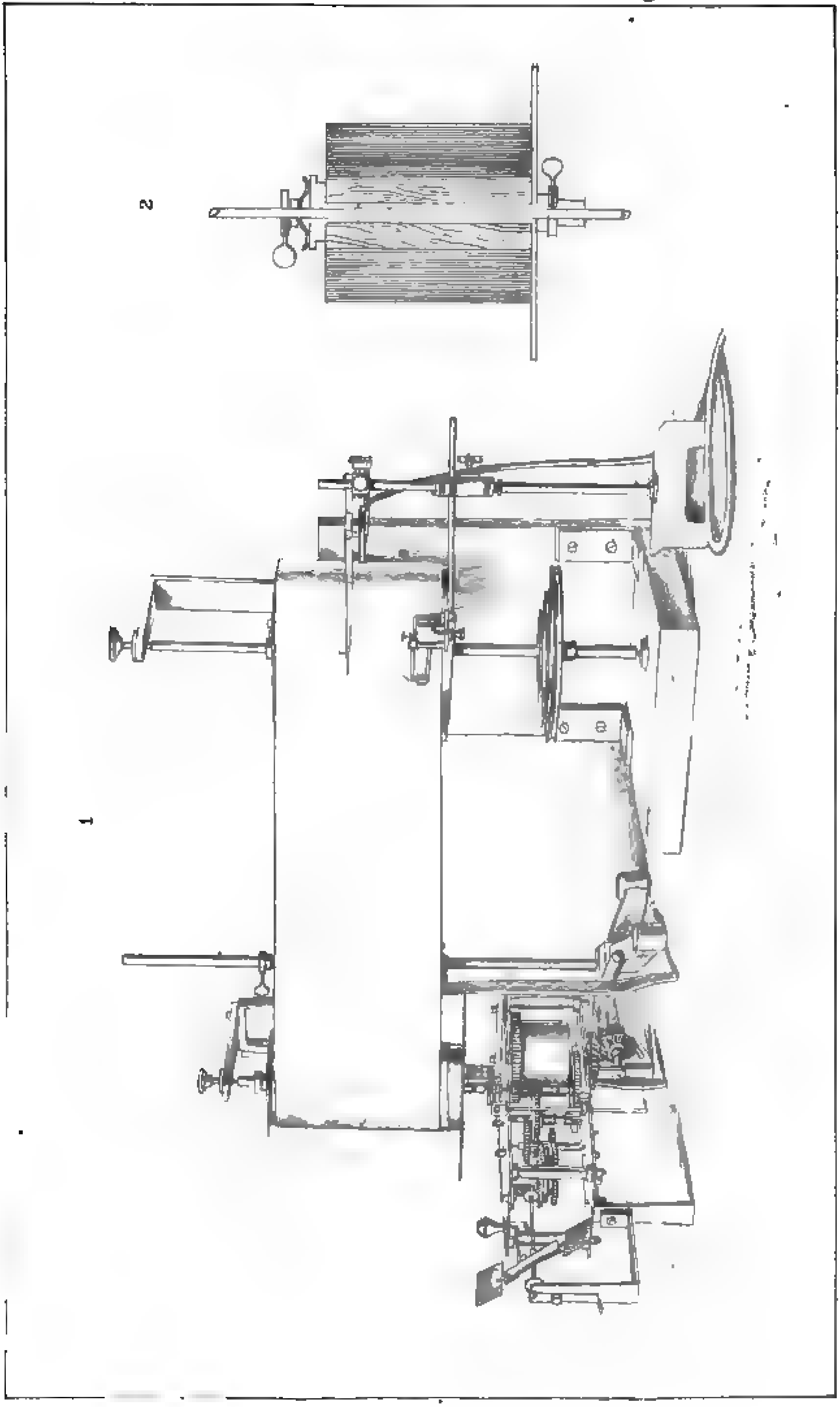

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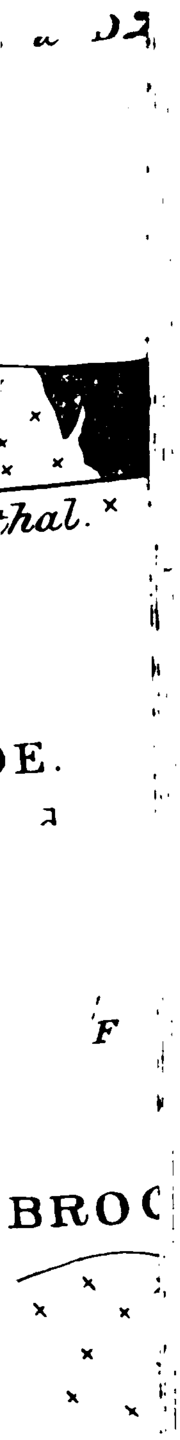

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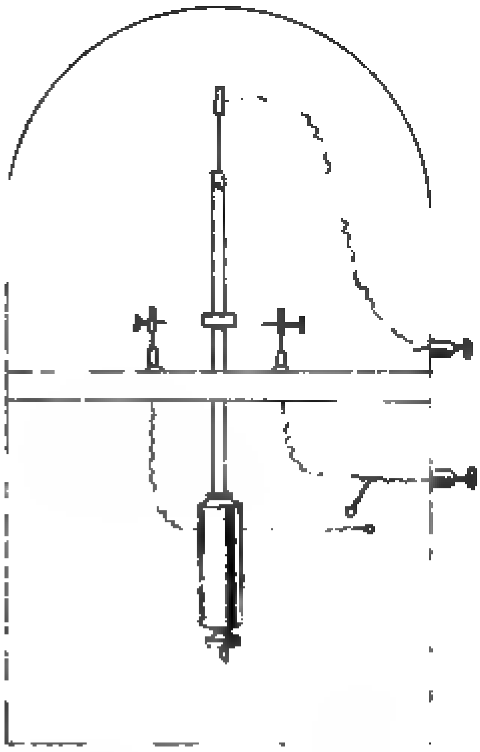

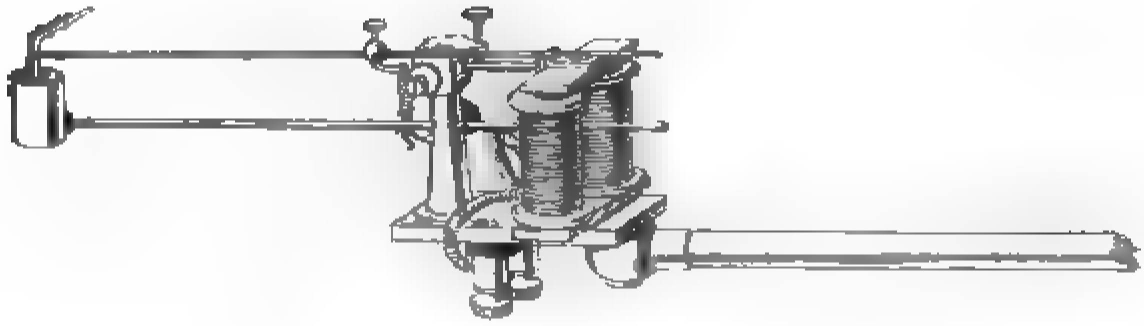

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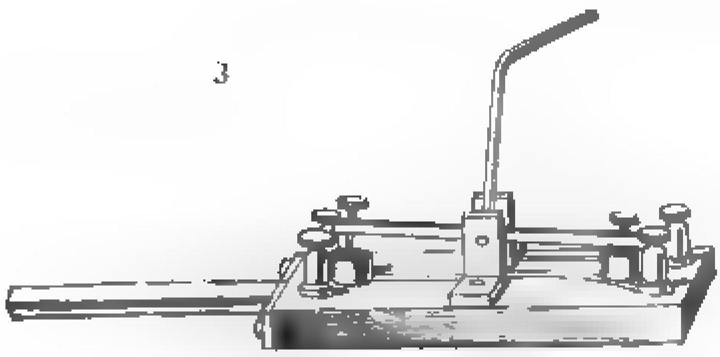

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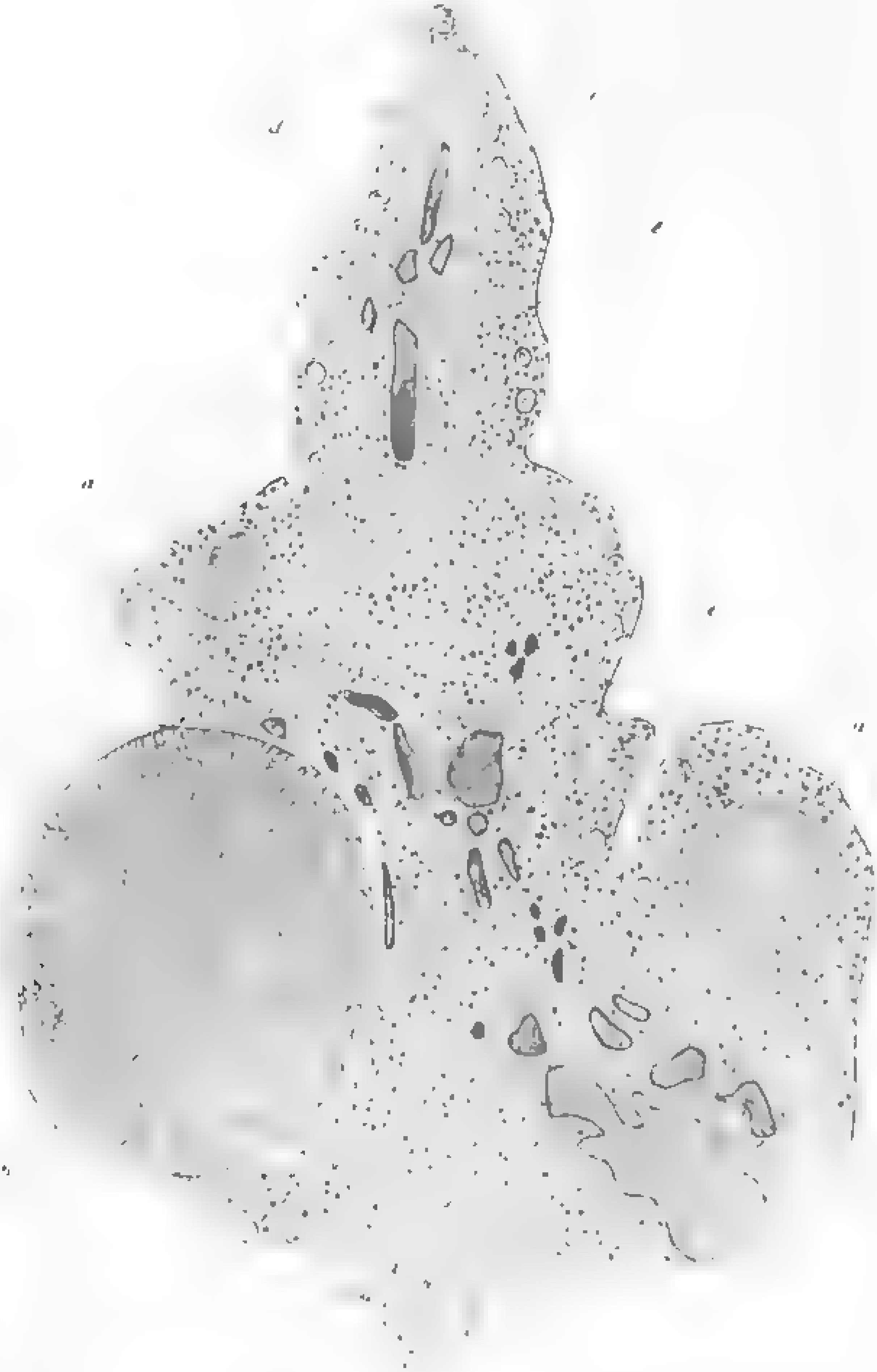

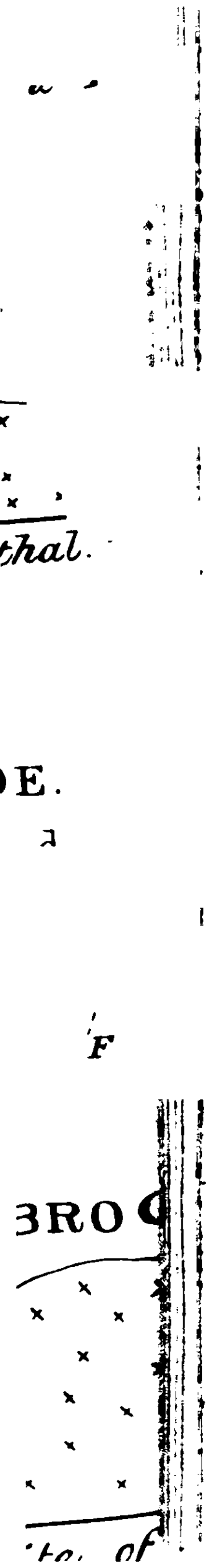
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Vol. VIII *Royal Physical Society Edinburgh.*

FIG 1.

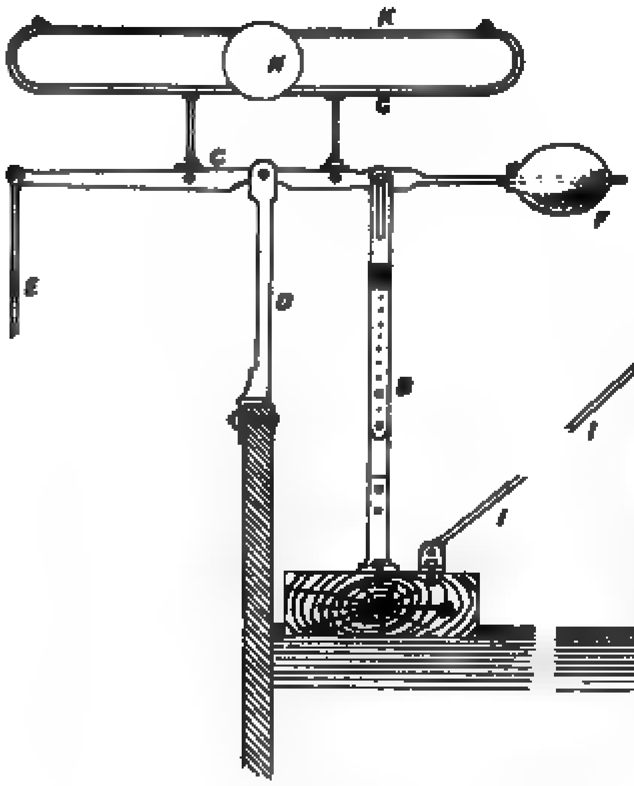

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FIG 2.

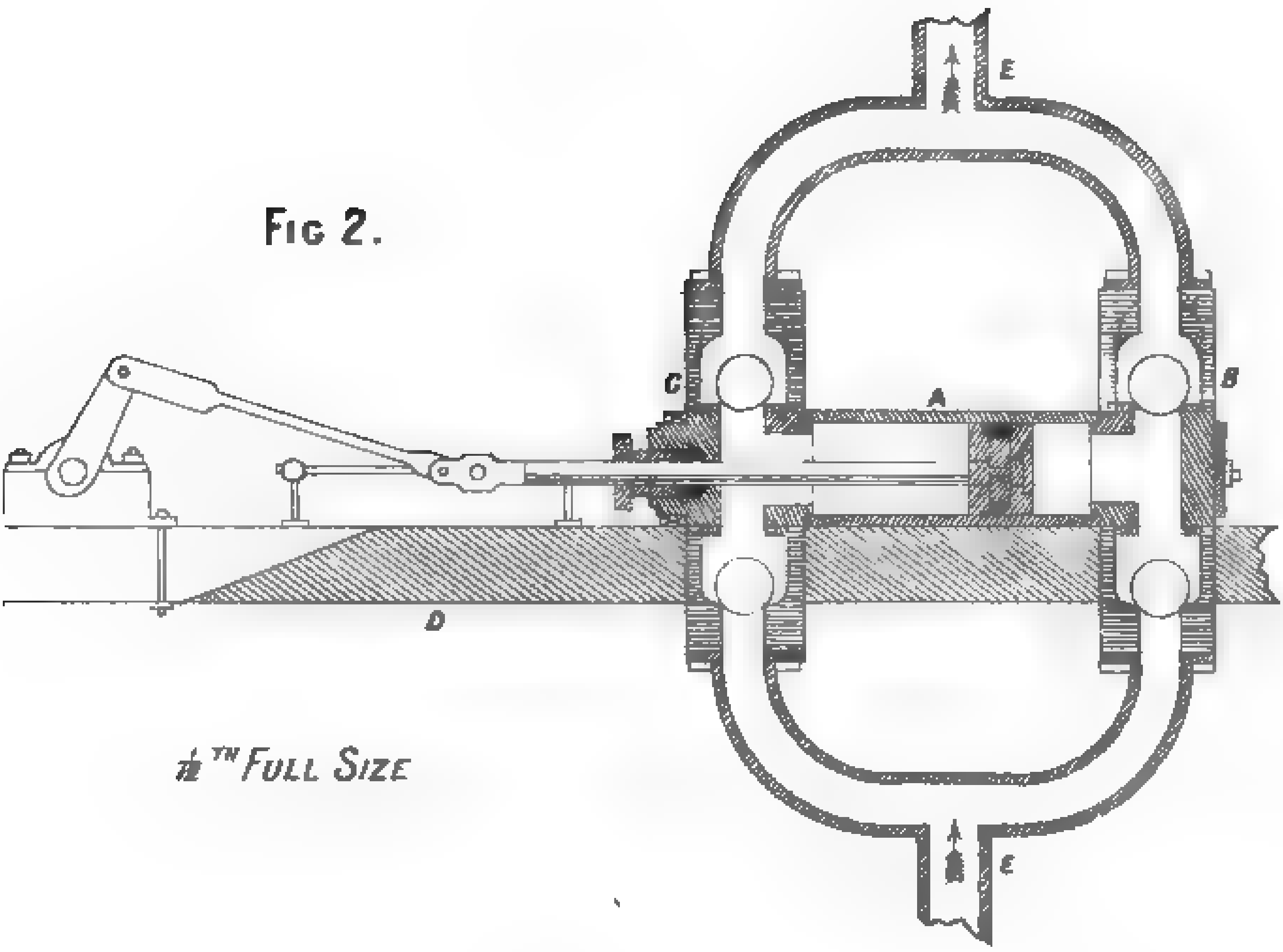

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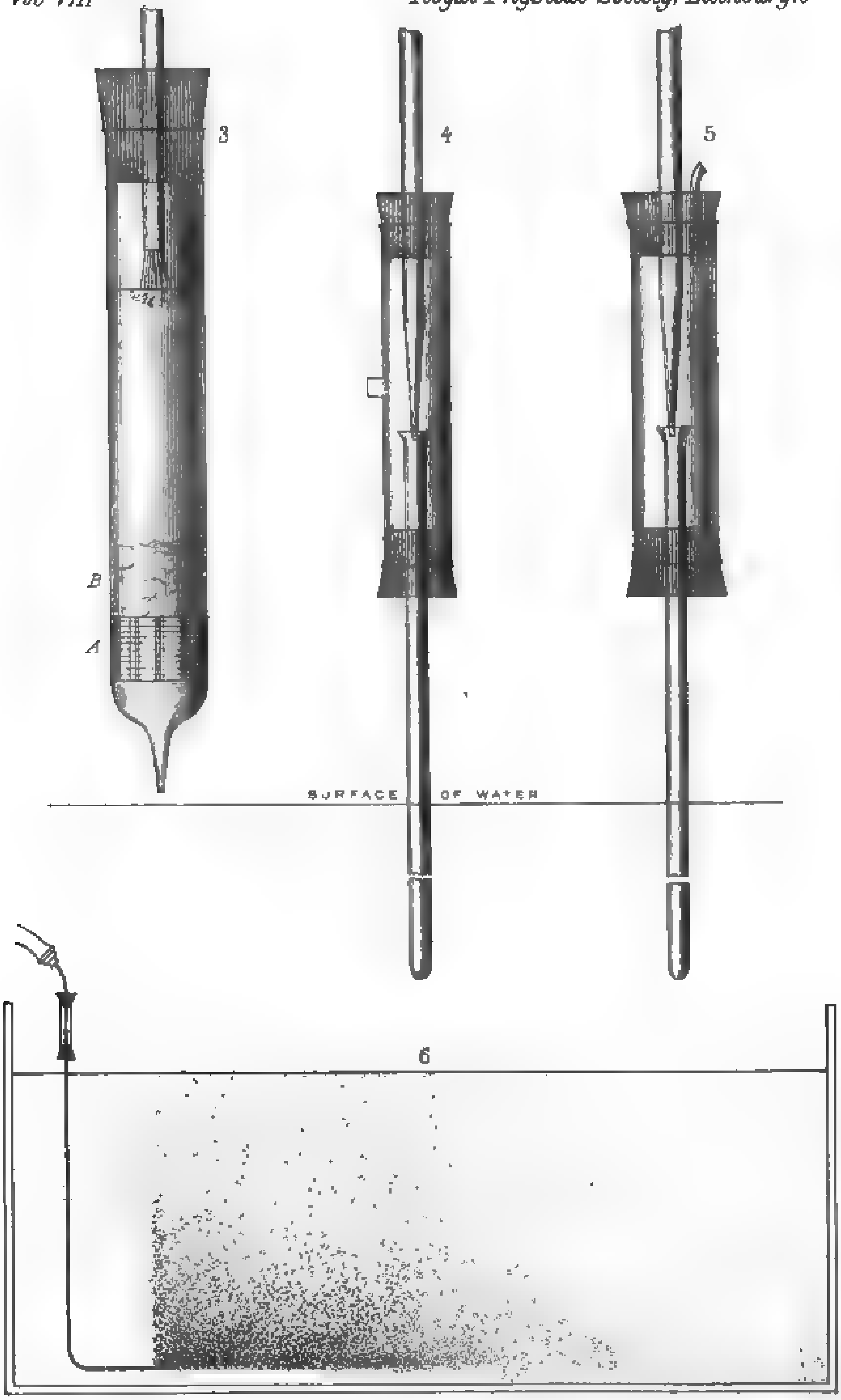
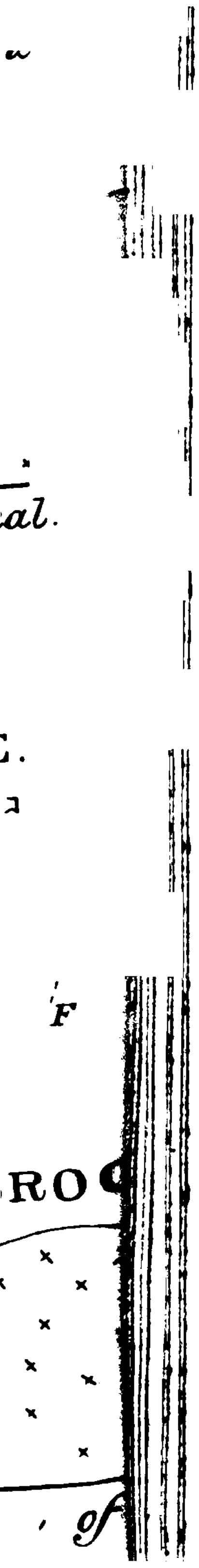
PLATE XIX

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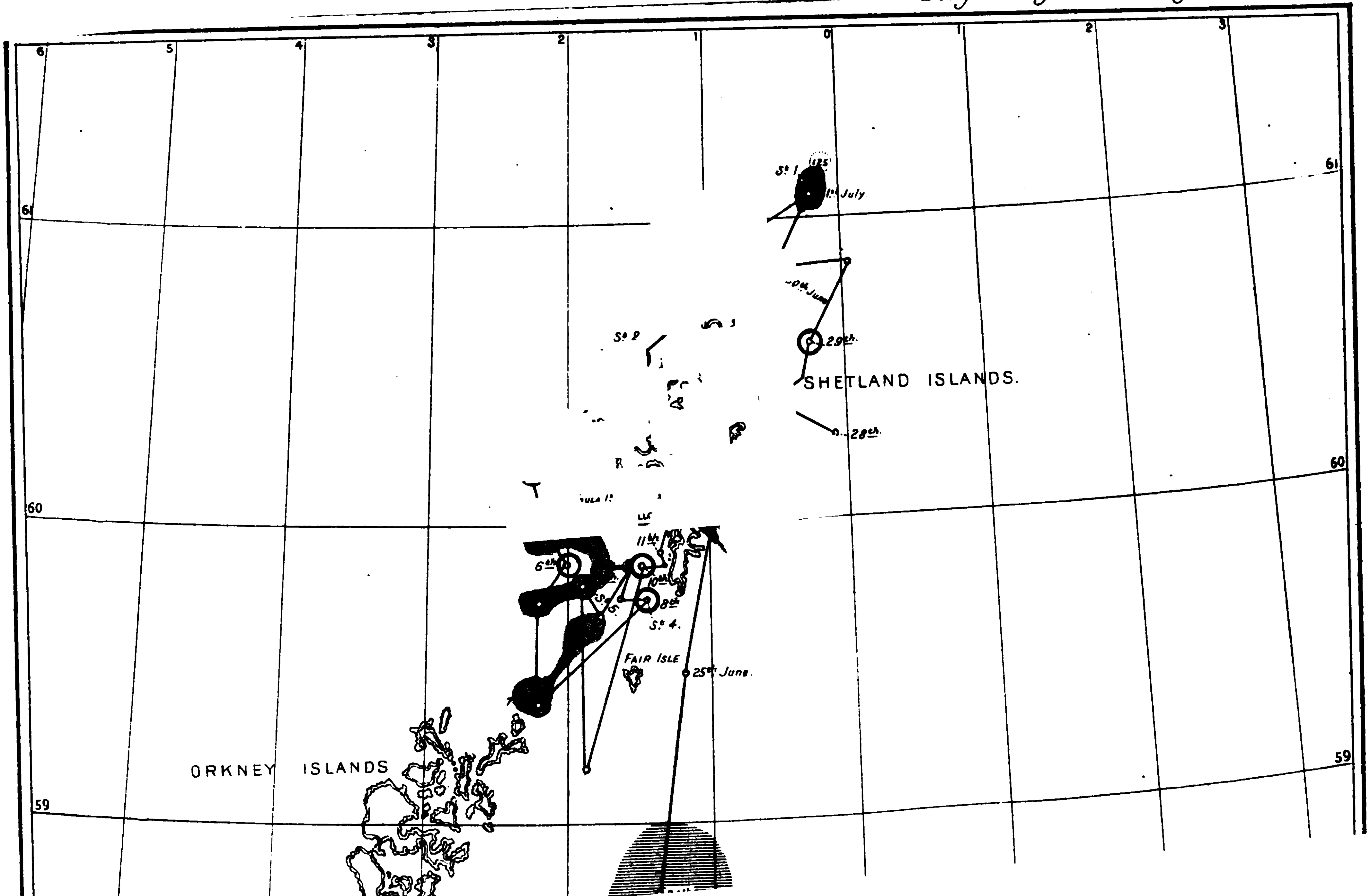

SHETLAND ISLANDS.
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FAIR ISLE
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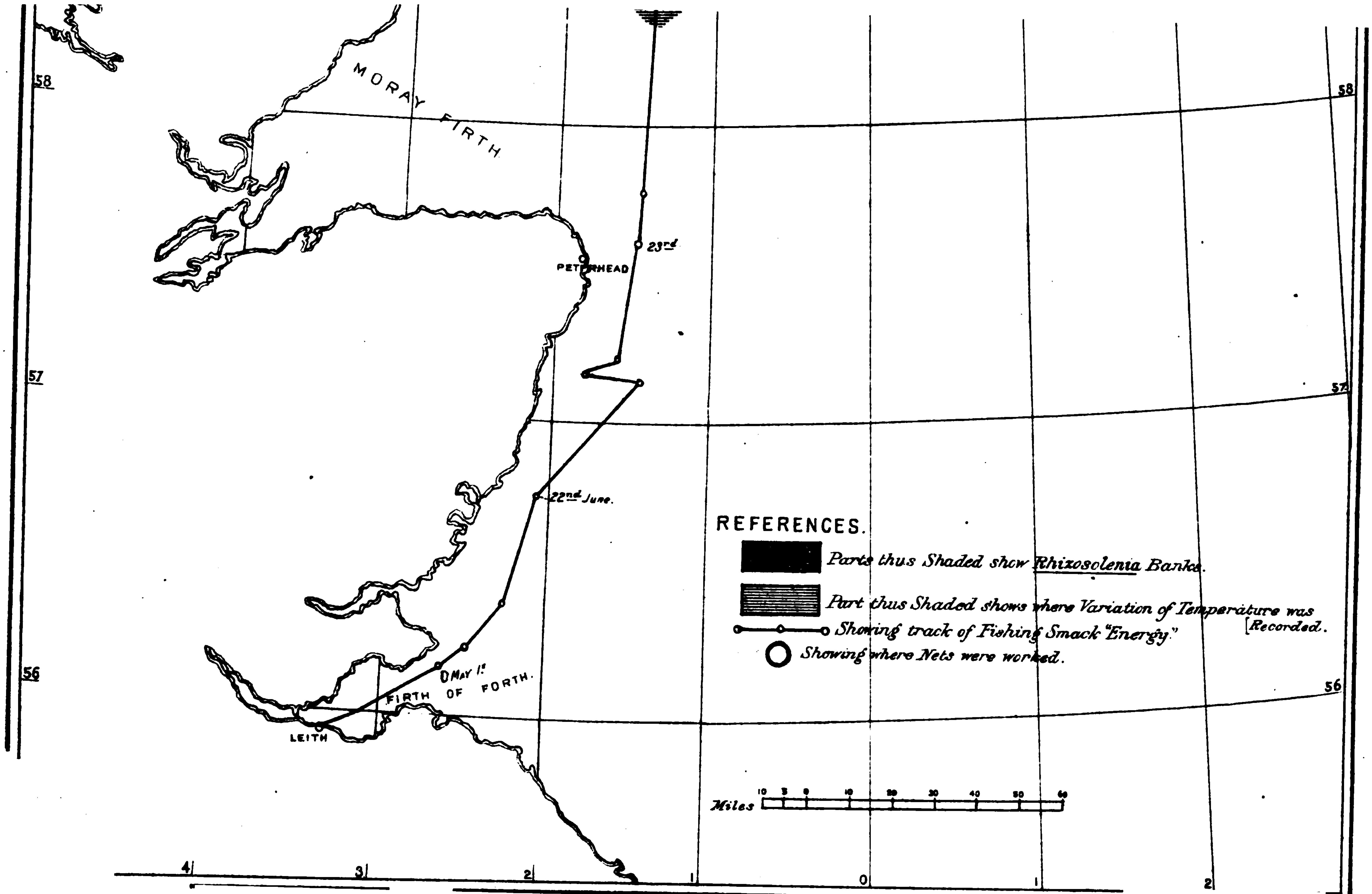
10th.
8th.
6th.


MORAY FIRTH
PETERHEAD
23rd
22nd June.
May 1st
FIRTH OF FORTH.
LEITH
REFERENCES.
Parts thus Shaded show Rhizosolenia Banks.
Part thus Shaded shows where Variation of Temperature was Recorded.
Showing track of Fishing Smack "Energy."
Showing where Nets were worked.
Miles
10 5 0 10 20 30 40 50 60
58
57
56
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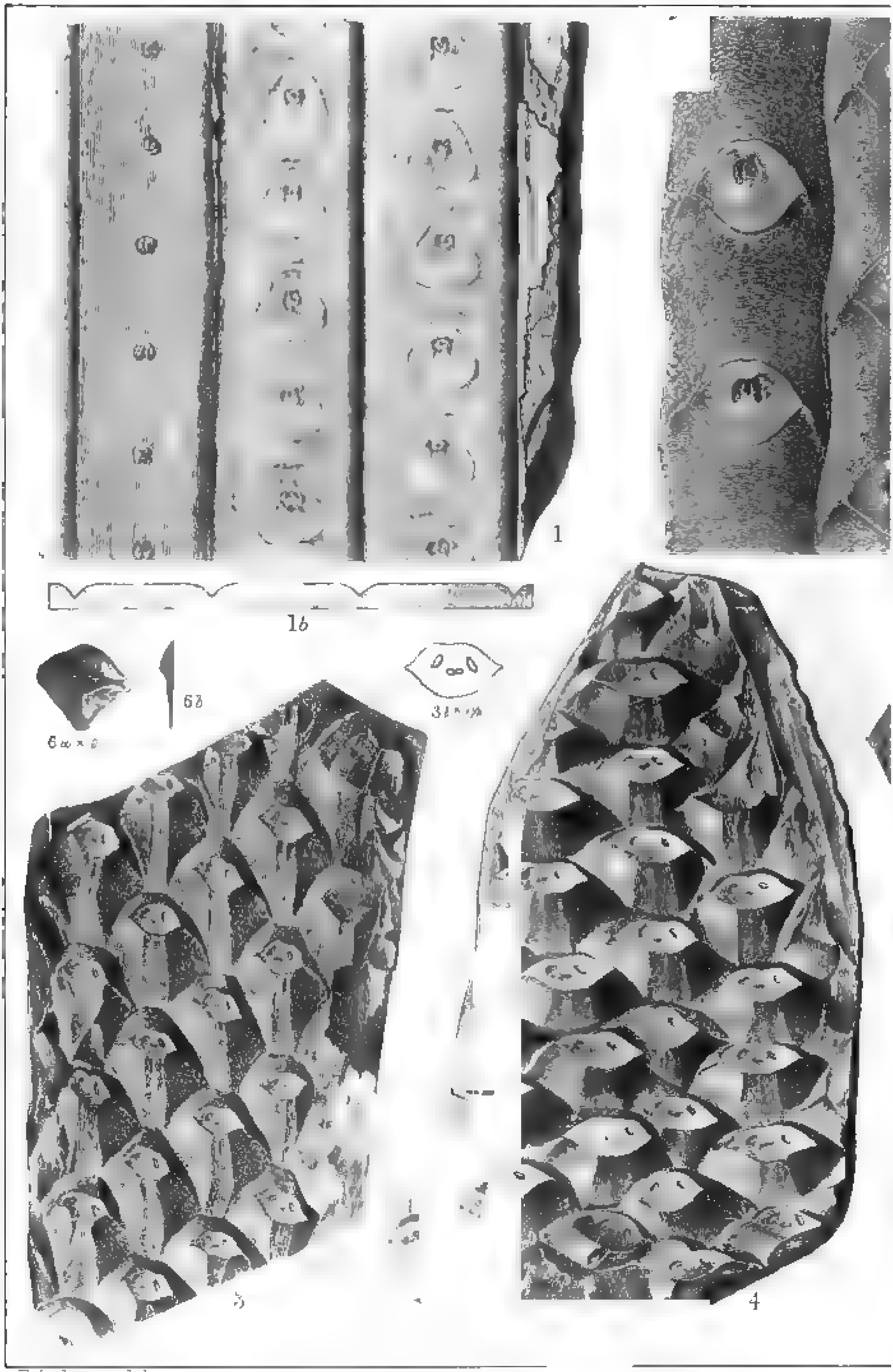

Fig 1 SIGILLARIA WALCHII, SAUV...
3-5 SIGILLARIA McMURTRIEI, KIDSTON n. s.

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GILLARIA CORIACEA, *Kidston, n.s*

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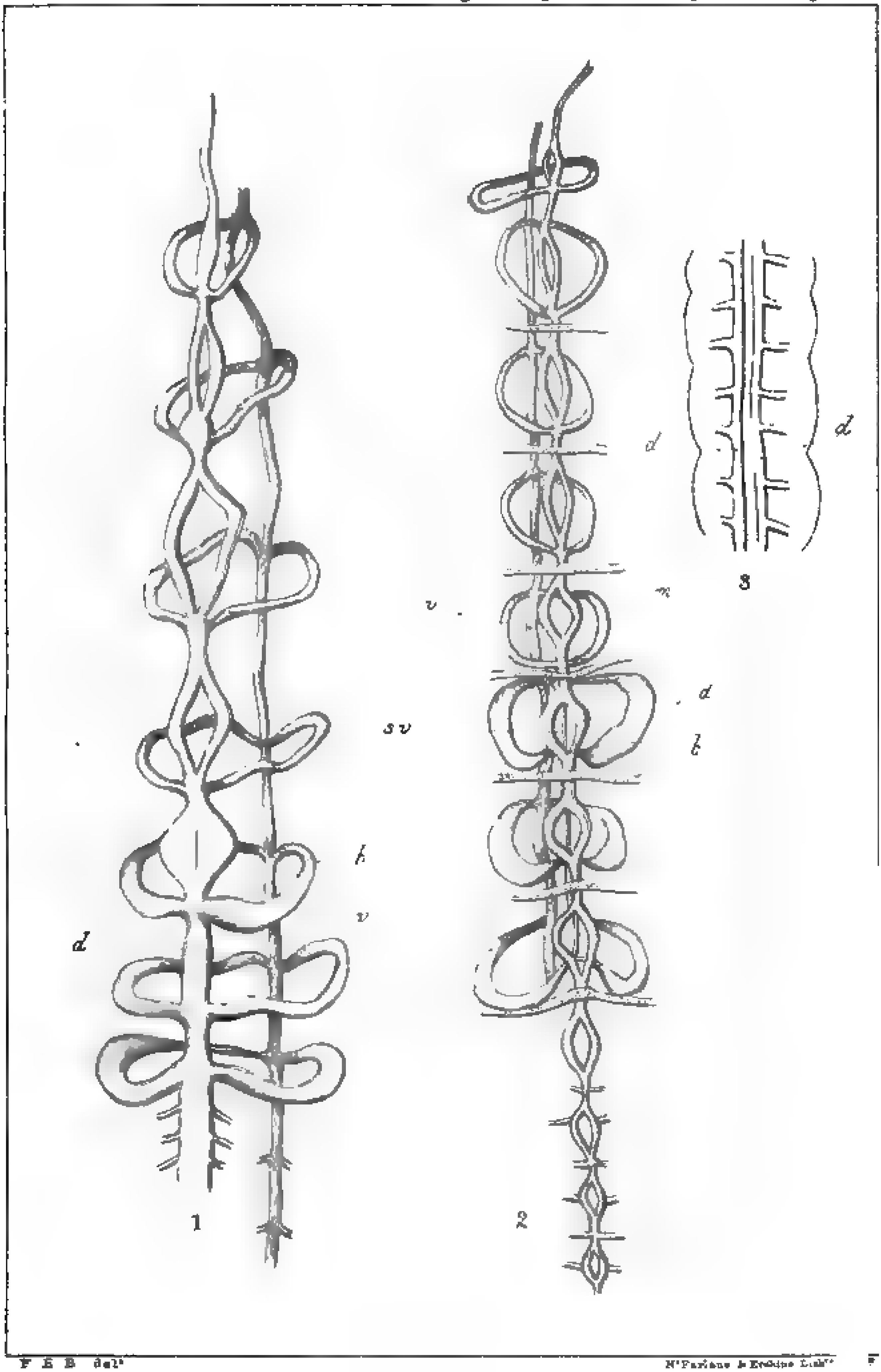
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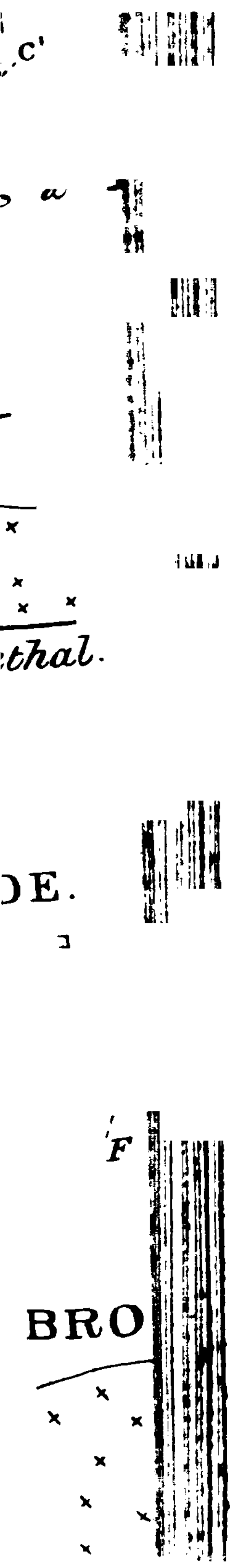
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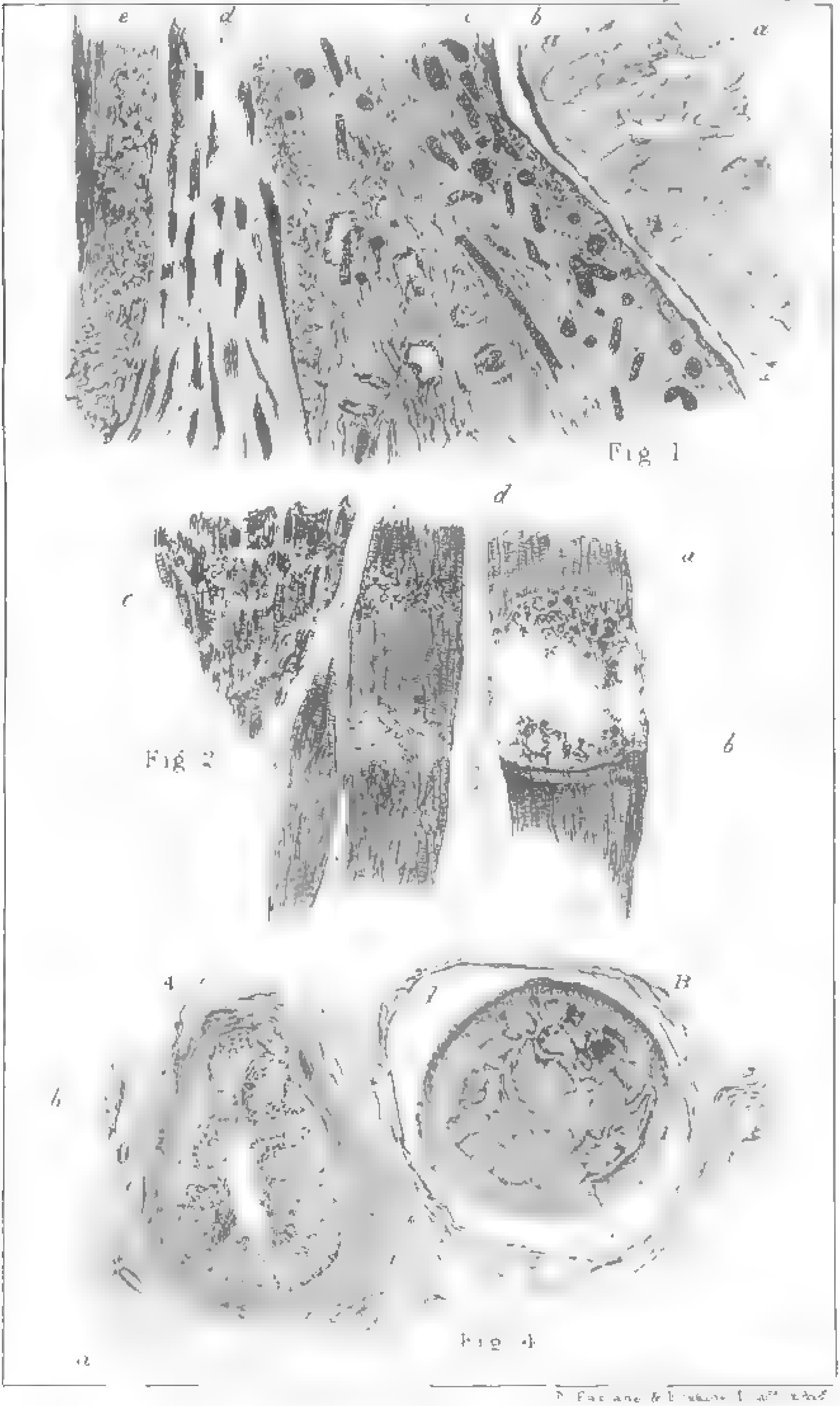
PLATE XXIII



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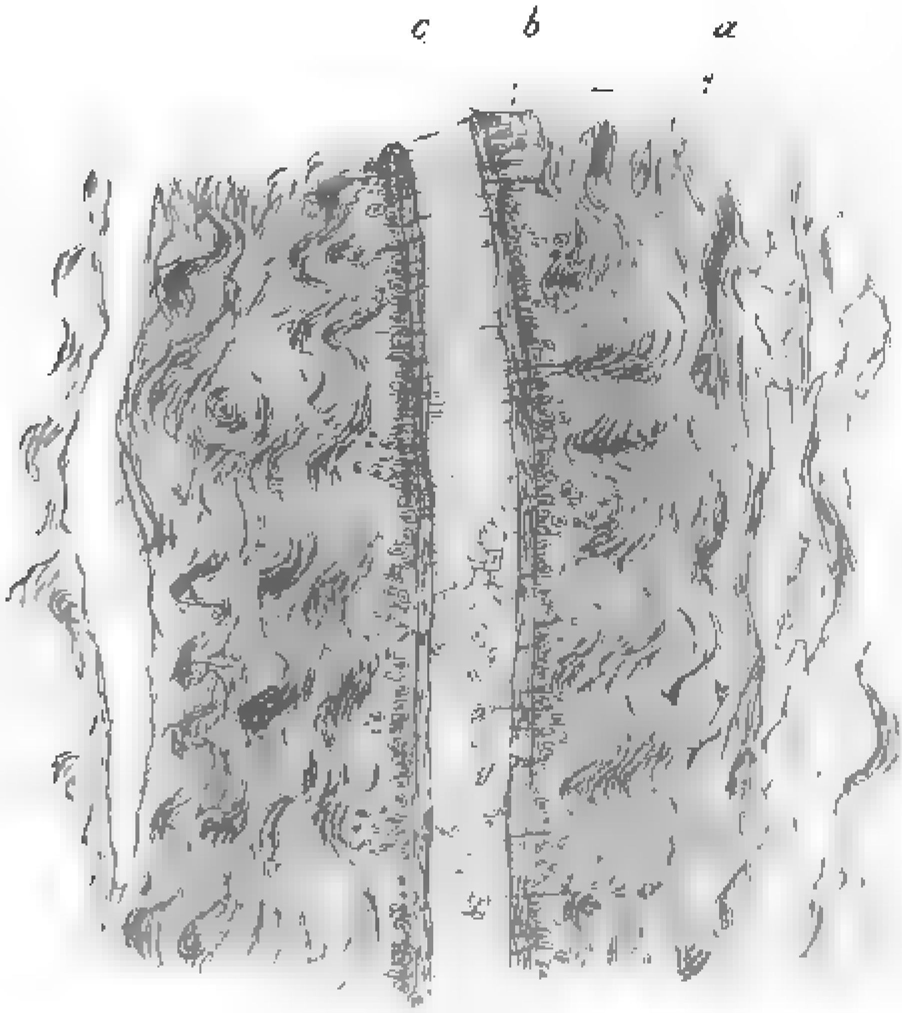

Fig 3

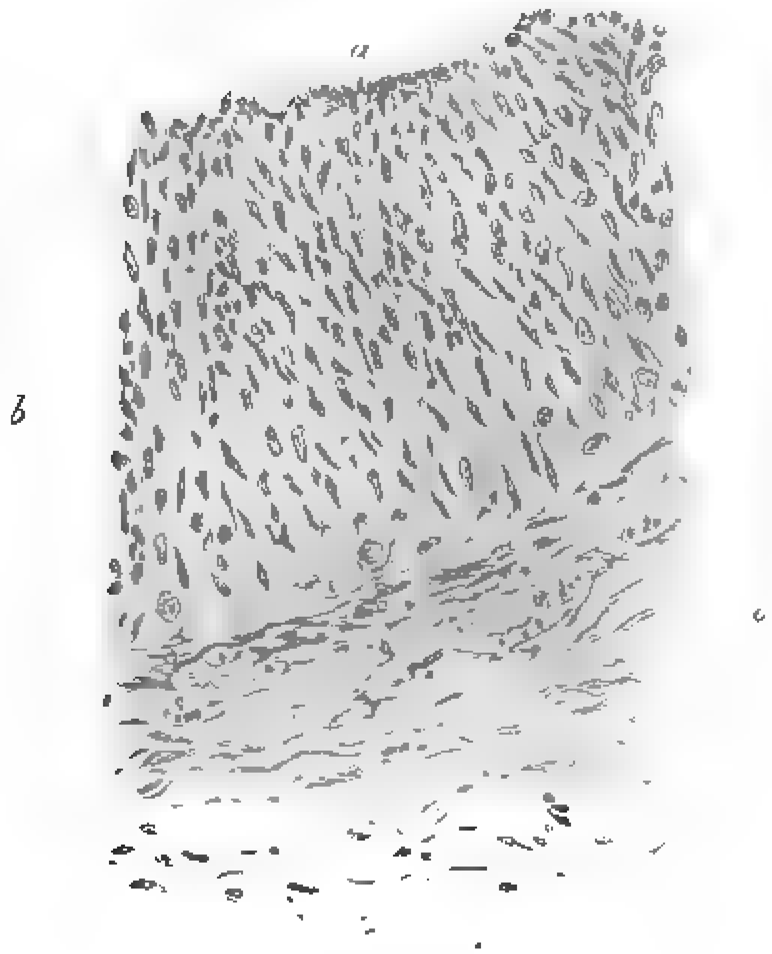

Fig 5

M Farlane & Erskine Lith^{rs} Edin^{r}

LIST OF SOCIETIES AND OTHER INSTITUTIONS THAT RECEIVE THE "PROCEEDINGS"

OF THE

ROYAL PHYSICAL SOCIETY OF EDINBURGH.

ENGLAND.

BIRMINGHAM, . .	Philosophical Society, King Edward's Grammar School.
CAMBRIDGE, . .	Philosophical Society.
Do. . .	University Library.
DURHAM, . .	University Library.
HERTFORDSHIRE, .	Hertfordshire Natural History Society and Field Club, Watford.
HALIFAX, . .	Yorkshire Geological and Polytechnic Society, Cheirnedge, Halifax.
LIVERPOOL, . .	Literary and Philosophical Society.
Do. . . .	Engineering Society, Royal Institution.
LONDON, . .	British Museum Library.
Do. . .	Royal Society, Burlington House, Piccadilly, W.
Do. . .	Chemical Society, Burlington House, Piccadilly, W.
Do. . .	Geological Society, Burlington House, Piccadilly, W.
Do. . .	Linnean Society, Burlington House, Piccadilly, W.
Do. . .	Royal Microscopical Society, King's College.
Do. . .	Museum of Economic Geology, Jermyn Street.
Do. . .	The Editor of *Nature*, 29 Bedford Street, Covent Garden.
Do. . .	Zoological Society, 3 Hanover Square.
Do. . .	Geologists' Association, University College.
MANCHESTER, .	Geological Society, 36 George Street.
Do. . .	Literary and Philosophical Society, 36 George Street.
Do. . .	Owen's College Library.
NEWCASTLE, . .	Philosophical Society.
NORWICH, . .	Norfolk and Norwich Naturalists' Society, The Museum.
OXFORD, . .	Bodleian Library.
TRURO, . . .	Royal Institution of Cornwall.

SCOTLAND.

ABERDEEN, . .	University Library.
COCKBURNSPATH, .	Berwickshire Naturalists' Club, Old Cambus.
EDINBURGH, . .	Advocates' Library.
Do. . .	University Library.

EDINBURGH,	Royal Society, Royal Institution.
Do.	Royal Medical Society, 7 Melbourne Place.
Do.	Royal Scottish Society of Arts, 117 George Street.
Do.	Botanical Society, Royal Botanic Garden.
Do.	Highland and Agricultural Society, George IV. Bridge.
Do.	Scottish Geographical Society, 80A Princes Street.
Do.	Geological Society, Surgeons' Hall.
GLASGOW,	Philosophical Society, Sauchiehall Street.
Do.	Natural History Society, 207 Bath Street.
Do.	Geological Society, 76 Henderson Street.
Do.	University Library.
PERTH,	Perthshire Society of Natural Science, Natural History Museum.
ST ANDREWS,	University Library.

IRELAND.

BELFAST,	Natural History and Philosophical Society.
DUBLIN,	Royal Irish Academy, 19 Dawson Street.
Do.	Royal Dublin Society, Kildare Street.

COLONIES.

ADELAIDE,	Royal Society of South Australia.
CALCUTTA,	Asiatic Society.
CANADA,	Library of Geological Survey, The Museum, Sussex Street, Ottawa.
Do.	Royal Society of Canada, Ottawa.
Do.	The Canadian Institute, Toronto.
Do.	The Historical and Scientific Society, Winnipeg, Manitoba.
Do.	Queen's University, Kingston.
Do.	Nova Scotia Institute of Natural Science, Halifax, Nova Scotia.
CAPE OF GOOD HOPE,	The Observatory.
MELBOURNE,	Royal Society of Victoria.
SHANGHAI,	North China Branch of the Asiatic Society.
SYDNEY,	Royal Society of New South Wales (Agents, Messrs Trübner and Co., 57 Ludgate Hill, E.C.).
Do.	Linnean Society of New South Wales.
WELLINGTON,	New Zealand Institute.

CONTINENT OF EUROPE.

AMSTERDAM,	De Koninklijke Akademie van Wetenschappen.
BASLE,	Die Schweizerische Naturforschende Gesellschaft.
BERLIN,	Konigliche Akademie der Wissenschaften.
Do.	Deutsche Geologische Gesellschaft.
Do.	Gesellschaft Naturforschender Freunde.
BERN,	Allgemeine Schweizerische Gesellschaft für die Gesammten-Naturwissenschaften.
BONN,	Niederrheinische Gesellschaft für Natur- und Heilkunde.
BOLOGNA,	Accademia delle Scienze dell' Istituto.

BORDEAUX,	La Société Linnéenne.
BREMEN,	Verein für Naturwissenschaft.
BRAUNSCHWEIG,	Naturwissenschaftlicher Verein.
BRUSSELS,	Académie Royale des Sciences, des Lettres, et des Beaux Arts.
Do.	La Société Belge de Microscopie.
CHRISTIANIA,	University Library.
Do.	Det Naturhistoriske Selskab.
COIMBRA, PORTUGAL,	University Library.
COPENHAGEN,	Kongel. Danske Videnskabernes Selskab i Kjöbenhavn.
Do.	Naturhistoriske Forening i Kjöbenhavn.
CHERBOURG,	Société Nationale des Sciences Naturelles.
DRESDEN,	Königliche Sammlungen für Kunst und Wissenschaft.
ELBERFELD,	Naturwissenschaftlicher Verein.
ERLANGEN,	University Library.
FRANKFORT-ON-MAIN,	Senckenbergische Naturforschende Gesellschaft.
GENEVA,	Société de Physique et d'Histoire Naturelle.
GÖTTINGEN,	Königliche Gesellschaft der Wissenschaften.
HALLE,	Kaiserliche Akademie der Naturforscher.
HERMANNSTADT, AUSTRIA,	Siebenbürgischer Verein für Naturwissenschaft.
JENA,	Medicin-Naturwissenschaftliche Gesellschaft.
LEIDEN,	Der Museum.
LEIPZIG,	Königliche Sächsische Gesellschaft der Wissenschaften.
LISBON,	Academia Real das Sciencias de Lisbon.
MADRID,	Real Academia de Ciencias.
MILAN,	Reale Istituto Lombardo di Scienze, Lettre ed Arti.
Do.	Società Italiana di Scienze Naturali.
MOSCOW,	Société Impériale des Naturalistes de Moscou.
MUNICH,	Königliche-Bayerische Akademie der Wissenschaften.
NEUFCHATEL,	Société des Sciences Naturelles.
PARIS,	Académie des Sciences de l'Institut.
Do.	Société Geologique de France, 7 Rue du Grand Augustine.
Do.	Société Zoologique de France, 7 Rue du Grand Augustine.
Do.	Société de Biologie.
Do.	Ecole des Mines.
PRAGUE,	Königliche-Böhmische Gesellschaft der Wissenschaften.
ROME,	Reale Accademia dei Lincei.
ST PETERSBURG,	Académie Impériale des Sciences.
Do.	Imperial St Petersburg Botanic Garden.
STOCKHOLM,	Konigliga Svenska Vetenskaps-Academie.
STUTTGART,	Verein für Vaterländische Naturkünde in Würtemberg.
TRIESTE,	Società Adriatica di Scienze Naturali.
TURIN,	Reale Accademia delle Scienze.
UTRECHT,	Provinciaal Genootschap an Kunsten en Wetenschappen.
UPSALA,	Kongliga Vetenskaps-Societeten.
VIENNA,	Zoologisch-Botanische Gesellschaft, Herrengasse 13.
WÜRZBURG,	Physikalisch-Medicinische Gesellschaft.
ZÜRICH,	Die Schweizerische Naturforschende Gesellschaft.

ASIA.

JAPAN, ...	Imperial University of Tokio.

AMERICA.

BALTIMORE, . . .	Johns-Hopkins University Library.
BOSTON, ...	American Academy of Arts and Sciences.
Do.	Society of Natural History.
CAMBRIDGE, MASS., U.S.,	Harvard University Library.
CHICAGO, ...	Academy of Sciences.
CINCINNATI, . . .	Society of Natural History, 108 Broadway.
MEXICO, ...	Ministerio de Fomento de la Republica Mexicana.
NEWHAVEN, U.S., . .	Academy of Arts and Sciences, Newhaven, Connecticut.
Do. . .	Yale College, Newhaven, Connecticut.
NEW YORK, . . .	State Library, Albany.
OHIO, ...	Mechanics' Institute.
PHILADELPHIA, . .	Academy of Natural Sciences.
RIO DE JANEIRO, . .	Museu Nacional.
SAN FRANCISCO, . .	The Californian Academy of Sciences, San Francisco.
ST LOUIS, ...	Academy of Sciences.
WASHINGTON, . . .	Smithsonian Institute.
Do. . . .	Philosophical Society.

DONATIONS

TO THE

LIBRARY OF THE ROYAL PHYSICAL SOCIETY

SESSIONS 1883-84 and 1884-85.

Quarterly Journal of the Geological Society, London, Nos. 154, 155, 156; Vol. 39, Nos. 157 and 158. *From the Society.*

Journal of the Royal Geological Society of Ireland, Vol. 6, Part 2. *From the Society.*

Transactions of the Zoological Society of London, Parts 8, 9, Vol. 11. *From the Society.*

The Journal of the Linnean Society (Zoology), Nos. 98 to 108. *From the Society.*

Proceedings of the Natural History Society of Glasgow, Vol. 5, Parts 2 and 3; Vol. 1, Part 1, New Series. *From the Society.*

Transactions of the Royal Society of Victoria, Vols. 19 and 20. *From the Society.*

The Journal of the Cincinnati Society of Natural History, Vol. 6, Nos. 1, 2, 3, 4; Vol. 7, Nos. 3 and 4; Vol. 8, No. 1. *From the Society.*

Proceedings of the Academy of Natural Sciences of Philadelphia, Parts 1, 2, 3, 1882; Parts 1, 2, 3, 1883; Parts 1 and 3, 1884; Part 1, 1885; also for the years 1857-65, and 1868 and 1876. *From the Academy.*

Congressional Directory, by B. P. POORE. *From the U.S. Government.*

Proceedings of the Canadian Institute, Toronto, Vol. 1, Nos. 4 and 5; Vol. 2, No. 3; Vol. 3, No. 1. *From the Institute.*

List of Animals in the Gardens of the Zoological Society of London, 1883, *cloth. From the Society.*

Annual Report of the Board of Regents of the Smithsonian Institution for the Years 1881, 1882.

Mathematische und naturwissenschaftliche Mittheilungen aus den Sitzungsberichten der königlichen preussischen Akademie der Wissenschaften zu Berlin, 1882, 1883, 1884 and 1885, hft. 1 to 5. *From the Academy.*

Annales de l'Observatoire de Moscou, Vol. 9, Parts 1, 2, 1883.

Annuaire de l'Académie Royale des Sciences des lettres et des Beaux Arts de Belgique, 1882, 1883. *From the Academy.*

Bulletins de l'Académie Royale des Sciences des lettres et des Beaux Arts de Belgique. Third Series, Vols. 1, 2, 1881; Vols. 3, 4, 1882; and Vol. 5, 1883. *From the Academy.*

Oversigt over det Kongelige Danske Vidensk. Selsk. Forhandlinger, 1882, 1883, 1884; and 1885, No. 1. *From the Royal Academy, Copenhagen.*

Natuurkundig Tijdschrift voor Nederlandsch Indië, Vol 41, Part 2; Vol. 43.

Zeitschrift der deutschen geologischen Gesellschaft, Vol. 25, Parts 1, 2, Vol. 35, Part 3; Vols. 36, and 37, hft. 1 (1885). *From the Society.*

Proceedings of the Society for Psychical Research, Vol. 1, Parts 2, 3. *From the Society.*

Scientific Proceedings of the Ohio Mechanics' Institute, Vol. 1, No. 2, Vol. 2, No. 3. *From the Institute.*

Bulletin de la Société Zoologique de France for 1883 and 1884. *From the Society.*

Proceedings of the Geologists' Association, Vol. 1, 10 Parts; Vol. 2, Part 1; Vol. 3, Part 5; Vol. 5, Parts 3, 4; Vol. 8, Nos. 2, 3, 5, 6, 8; Vol. 9, No. 1. *From the Association.*

Transactions of the Geological Society of Glasgow, Vol. 1, Part 2; Vol. 4; Vol. 5, Part 1; Vol. 6, Part 1; Vol. 7. *From the Society.*

American Journal of Mathematics, Vols. 3-7, Part 2. *From the Johns-Hopkins University.*

American Chemical Journal, Vols. 1-6, No. 5. *From the Johns-Hopkins University.*

University Circulars, Vols. 1-4, Nos. 34-39. *From the Johns-Hopkins University.*

Transactions of the Norfolk and Norwich Naturalists' Society, Vols. 1, 2, and 3. *From the Society.*

Acta Horti Petropolitani (Proceedings of the Imperial Botanic Garden of St Petersburg), Tome 6, Part 2, to Tome 9, Part 1. *From the Director.*

Quarterly Journal of the Geological Society, Vol. 40, Parts 3 and 4; Vol. 41, Part 1 (1885). *From the Society.*

Journal and Proceedings of the Hamilton Association of Canada, Vol. 1, Part 1 (1882-83). *From the Association.*

Memoirs of the Wernerian Society, Vol. 1. *Purchased.*

History of the Royal Medical Society, by Dr William Stroud, Edinburgh, 1810. *From the Society.*

Transactions of the Edinburgh Geological Society, Vol. 2, Part 3. *From the Society*

Proceedings of the Zoological Society, Vols. 25 and 26 (1857 and 1858); Part 4, 1882; Vols. 1883 and 1884. *From the Society.*

A Monograph of the British Phytophagous Hymenoptera, by P. Cameron. Vol 2 (Ray Society publication). *Subscribed for.*

Historical Sketch of the Royal College of Physicians of Edinburgh, with Laws and List of the Fellows (Edin. 1882). *From the College.*

Videnskabelige Meddelelser fra den Naturhistorisk Forening i Kjöbenhavn, 1849, No. 7; 1867, Nos. 1-7; 1882; 1883, Part 1; Index, 1849-68; and 1883, Part 2. *From the Society.*

Jameson's System of Mineralogy (3 Vols.). *From A. A. Murdoch, Esq.*

Transactions of the Highland and Agricultural Society of Scotland, Vols. 1-13, and Vols. 15 and 16 (Fourth Series). *From the Society.*

Report on the Agriculture of Scotland, presented to the International Agricultural Congress at Paris, 1878. *From the Highland and Agricultural Society.*

Annales de Ministerio de Fomento de la Republica Mexicana, Tomes 2, 3, and 7. *From the Republic.*

Proceedings of the Belfast Natural History and Philosophical Society for 1871-72 and 1874-84. *From the Society.*

Jahreshefte des Vereins fur Vaterländische Naturkunde in Württemburg, 1878-84 (7 vols.); and 1885, hft. 1. *From the Society.*

Smithsonian Miscellaneous Collections, Vols. 12-27. *From the Institute.*

Smithsonian Reports for 1853-54-57-64-66-67-70-73-74-75-76. *From the Institute.*

Proceedings of the Linnean Society of London, November 1882 to June 1883. *From the Society.*

Proceedings of the Berwickshire Naturalists' Club, Vol. 10, Nos. 1 and 2. *From the Club.*

Studies in Microscopical Science, Vol. 1. *From the Editor.*

Check List of Insects of the Dominion of Canada compiled by the Natural History Society of Toronto, July 1883. *From the Society.*

Jahresbericht des Vereins für Erdkunde zu Dresden, 18, 19, and 20.

Annuario del Observetorio Astronómico Nacional de Tacubaya for the year 1884.

Revista Mansual Climato logica, Vol. 2, No. 12. *From the Mexican Government.*

Reports of the Medical and Surgical Registrars of the Middlesex Hospital for 1880, 1882, and 1883. *From the Hospital.*

Proceedings of the Boston Society of Natural History, Vol. 21, Part 4; Vol. 22, Parts 1, 2, and 3. *From the Society.*

Proceedings of the American Academy of Arts and Sciences, Vols. 1-16. *From the Academy.*

Memoirs of the Boston Society of Natural History, Vol. 3, Nos. 6-10. *From the Society.*

Proceedings of the Literary and Philosophical Society of Liverpool, Vols. 35, 36, 37. *From the Society.*

The Asclepiad, Vol. 1, No. 2; and Vol. 2, No. 5. By Dr B. W. RICHARDSON, F.R.S. *From the Author.*

Report of the Geological and Natural History Survey of Canada, 1880-82. *From the Director, Alfred R. C. Selwyn, LL.D., F.R.S.*

Bulletin of the Californian Academy of Science, No. 1, 1884; Nos. 2 and 3, 1885. *From the Academy.*

Transactions of the Royal Society of Edinburgh, Vols. 13-20; Vol. 21, Part 2; Vol. 30; and Vol. 32, Part 1. *From the Society.*

Proceedings of the Royal Society of Edinburgh, Vols. 1, 2, 3, 11, and 12. *From the Society.*

Journal of the Royal Society of New South Wales, Vol. 17. *From the Society.*

Proceedings of the Cambridge Philosophical Society, Vols. 1, 2, and 3; Vol. 4, Parts 4-6; Vol. 5, Parts 1 and 2. *From the Society.*

On a New Organ of Respiration in the Tunicata, by Professor W. A. HERDMAN, D.Sc., F.R.S.E. etc. *From the Author.*

Proceedings of the Perthshire Society of Natural Science, Vol. 1, Parts 1, 2, and 4; Vol. 2, Part 3. *From the Society.*

Transactions of the Manchester Geological Society, Vol. 13, Part 2; Vol. 14, Parts 7 and 17; Vol. 17, Parts 7-18; Vol. 18, Parts 1-9. *From the Society.*

Descriptive Sketch of the Physical Geography and Geology of the Dominion of Canada, by Messrs SELWYN and DAWSON. *From the Geological Survey of Canada.*

Comparative Vocabularies of the Indian Tribes of British Columbia, with maps by Messrs TOLMIE and DAWSON. *From the Geological Survey of Canada.*

Studies from the Biological Laboratory of the Johns-Hopkins University. Vol. 2, Nos. 2, 3, and 4. *From the University.*

Transactions of the Botanical Society of Edinburgh, Vols. 1, 3, 4, and 5; Vol. 2, Part 3; Vol. 9, Part 2; Vol. 11, Part 2; Vol. 13, Part 1; Vol. 14, Part 3; Vol. 15, Part 1; and Vol. 16, Part 1. *From the Society.*

U.S. Geological Survey Reports. (1.) Vol. 3, Tertiary Vertebrata, B. 1. (2.) Vol. 8, The Cretaceous and Tertiary Floras. *From the Hon. the Secretary of the Interior, U.S.A.*

Bulletin, U.S. Geological Survey, Vol. 6, No. 2. *From the Hon. the Secretary of the Interior, U.S.A.*

Miscellaneous Publication, U.S. Geological Survey, Bibliography of North American Invertebrate Palæontology. *From the Hon. the Secretary of the Interior, U.S.A.*

Transactions of the Royal Scottish Society of Arts, Vol. 1, Parts, 3, 4, and Appendix; Vol. 2; Vol. 10, Part 5; Vol. 11, Parts 1 and 2. *From the Society.*

Transactions of the Hertfordshire Natural History Society, Vol. 3, Parts 1, 2, 3, and 4. *From the Society.*

Transactions of the Royal Dublin Society, Vol. 1 (New Series); Vol. 2; Vol. 3, Parts 1-6. *From the Society.*

Proceedings of the Royal Dublin Society, Vols. 1 and 2; Vol. 3, Parts 6 and 7; Vol. 4, Parts 1-6. *From the Society.*

Proceedings of the Philosophical Society of Glasgow, Vols. 2, 3, 4, 14, and 15. *From the Society.*

Remarks upon the Theory of Heredity. By Professor W. A. HERDMAN, D.Sc., F.R.S.E. *From the Author.*

Account of Edinburgh University Tercentenary Festival. Edited by R. SYDNEY MARSDEN, D.Sc., F.R.S.E. *From Dr Marsden.*

Agricultural Students' Gazette, Vol. 2, Part 3; Vol. 6, Part 6; Vol. 7, Part 1 (New Series). *From the Editors.*

Thirteen Volumes of Dissertations for the degree of M.D. in the University of Edinburgh. *From Professor J. Duns, D.D., F.R.S.E.*

Berichte der Naturforschenden Gesellschaft zu Leipzig, 1883. *From the Society.*

The Argentine Republic as a field for European Emigration—Official Publication. Edited by FRANCIS LATZINA. *From the Republic.*

Nova Acta, Reg. Soc. Scientiarum Upsaliensis (Third Series), Vol. 11, Fasc. 2; Vol. 12, Fasc. 1. *From the Society.*

Études sur Les Mouvements de L'Atmosphère, par Professors C. M. GULDBERG et H. MOHN. *From the Authors.*

Bidrag til Kundskaben om blodets Farvestoffe, af JAC. G. OTTO. *From the Author.*

On Magnets, by O. A. L. PHIL. *From the Author.*

Om Attractionen mellem to Cirkelperipherier, by O. PHIL. *From the Author.*

Om de Spektrophotometriske Kenstanters Variation, af J. G. OTTO. *From the Author.*

Om Oxyphæmoglobin af Svineblod, af JAC. G. OTTO. *From the Author.*

Om Svovlsyrens galvaniske Ledningsevne og. dennes Afhængighed af Temperaturen, af S. HENRICHSEN. *From the Author.*

Proceedings of the Birmingham Philosophical Society, Vol. 1, Nos. 1, 2, 3; and No. 4, Part 1.

Proceedings of the Nova Scotia Institute of Natural Science, Vol. 6, Part 2. *From the Institute.*

Transactions of the Connecticut Academy of Arts and Sciences, Vols. 1-3; Vol. 4, Parts, 1, 2; Vol. 5; and Vol. 6, Part 1. *From the Academy.*

Journal of the Royal Microscopical Society, London, Vol. 5, Parts 1, 2. *From the Society.*

Mémoires de l'Académie Impériale des Sciences de St Petersbourg, 7e série, Tomes 1-29 (1858-81); Tome 31, Nos. 1-16; Tome 32, Nos. 1-3. *From the Academy.*

Bulletin de l'Académie Impériale des Sciences de St Petersbourg, Tomes 1-27 (1854-81); Tome 28, Nos. 3, 4; Tome 29, Nos. 1-4; Tome 30, No. 1 (1885). *From the Academy.*

Compte Rendu, de la Société Helvetique des Sciences Naturelles, 1882 and 1883. *From the Society.*

Compte Rendu, de la Société de Physique et D'Histoire Naturelle de Genève, 1884. *From the Society.*

Verhandlungen der schweizerischen naturforschenden Gesellschaft in Zürich, Jahresbericht, 1881-82 and 1882-83. *From the Society.*

Boletin del Ministerio de Fomento de la Repûblica Mexicana, Tomo 9, Nos. 65-80; Tomo 10, Nos. 1-6. *From the Republic.*

Transactions of the Manitoba Historical and Scientific Society, Nos. 5-18; and a History of Hudson's Bay (our Northern Waters), by C. N. BELL, Vice-President. *From the Society.*

Johns-Hopkins University Circulars, Vol. 4, Nos. 37 and 38. *From the University.*

Proceedings of the Yorkshire Geological and Polytechnic Society, Vols. 6, 7 (1871-81); and Vol. 8, Parts 2, 3. *From the Society.*

Proceedings of the Royal Society of London, Nos. 89, 91, 106, 110, 112, 127, 143, 144, 158, 159, 178; and Vols. 26, 28, and 38, No. 236; Nos. 224-228; Vol. 37, No. 32. *From the Society.*

Transactions of the Liverpool Engineering Society, Vols. 1-5. *From the Society.*

Memoir of Dr Wilson of Bombay. *From Professor Duns, D.D., F.R.S.E.*

Memoirs of the Californian Academy of Sciences, Vol. 1, Parts 1, 2. *From the Californian Academy.*

Proceedings of the Californian Academy of Sciences, Vol. 2; Vol. 3, Parts 1, 2, 4, 5; Vol. 4, Parts 1, 2, and 4. *From the Californian Academy.*

Catalogue of Pacific Coast Fungi. *From the Californian Academy.*

Transactions of the Royal Irish Academy, Vols. 1-26; Vol. 27, Parts 1-5; Vol. 28, Parts 1-18; Vol. 24 (Antiquities), Vol. 24 (Polite Literature), Parts 1-4; and Cunningham Memoirs, No. 1. *From the Academy.*

Proceedings of the Royal Irish Academy, Vols. 1-6; Vol. 10, First Series; Vol. 2, Nos. 1-5; Vol. 3, New Series. *From the Academy.*

Abhandlungen der Mathemat. Naturwissenschaftl. Classe der König. Böhmischen Gesellschaft der Wissenschaften (Prague) 1883-84. *From the Society.*

Bericht der Mathemat. Naturwissenschaftl. Classe der König. Böhmischen Gesellschaft der Wissenschaften (Prague) 1884, Heft 1. *From the Society.*

Verzeichniss der Mitglieder der König. Bohmisch. Gesellschaft der Wissenschaften, 1784-1884. *From the Society.*

Sitzungs-berichte der Mitglieder der König. Bohmisch. Gesellschaft der Wissenschaften, 1884. *From the Society.*

Jahresbericht der Mitglieder der König. Bohmisch. Gesellschaft der Wissenschaften, 1884. *From the Society.*

On a Silurian Scorpion from Gothland. By J. THARALL and G. LINDSTRÖM. *From Professor Lindström, Correspond. F.R.P.S.*

Berichte der Mathemat. Phys. Classe der König. Sächsischen Gesellschaft der Wissenschaften zu Leipzig, Bande 26-36 (1874-84). *From the Society.*

Abhandlungen der Mathemat. Phys. Classe der König. Sächsischen Gesellechaft der Wissenschaften zu Leipzig, Bande 11, 12, 13 (Nos. 1-3). *From the Society.*

Canadian Journal, Vols. 1-3, First Series (1852-55) ; Vol. 1 ; Vol. 5, No. 29 ; Vol. 6, Nos. 33, 34 ; Vol. 10, No. 56 ; Vol. 11, No. 62 ; Vol. 14, No. 4 ; and Vol. 15, No. 6, Second Series. *From the Canadian Institute.*

Bulletin of the Brookville Society of Natural History, No. 1. *From the Society.*

Catalogue of Canadian Plants, Part 2—Gamopetalæ. By J. MACOUN, M.A., etc. *From the Geological Survey of Canada.*

Report and Maps of the Geological and Natural History Survey of Canada, 1882-84. *From the Geological Survey of Canada.*

Verhandlungen der Naturforschenden Gesellschaft in Basel, Bande 6 ; and 7, Hefte 1 and 2, and Supp. *From the Society.*

Annexe explicative à la Carte Géologique Générale de la Suède, par Professor A. G. NATHORST, and accompanying Map. *From Professor Nathorst, Correspond. F.R.P.S.*

Sitzungsberichte der Mathemat. physikalischen Classe der König. Akademie der Wissenschaften zu München, 1871-85, Bande 1-12 ; Band 13, Heft 1 ; Band 14. *From the Academy.*

Bulletin de la Société Géologique de France, Tomes 9-12 ; Tome 13, Part 3, Third Series. *From the Society.*

The Scottish Geographical Magazine, Vol. 1, Nos. 1-6. *From the Scottish Geographical Society.*

On the Cat Stone, Edinburghshire. By Sir J. Y. SIMPSON, Bart. *From Professor Duns, D.D., F.R.S.E.*

Antiquarian Notices of Syphilis in Scotland. By Sir J. Y. SIMPSON, Bart. *From Professor Duns, D.D., F.R.S.E.*

The Argument *a priori*. By W. H. GILLESPIE. *From Professor Duns, D.D., F.R.S.E.*

Comptes Rendus, Tome 100. *From the Academy of Sciences, Institute of France.*

Notice sur les lois de Frottement. Par G. A. HIRN. *From the Author.*

The National Geological Surveys of Europe. By WM. TOPLEY, F.G.S., etc., of H.M. Geological Survey. *From the Author.*

LIST OF FELLOWS.

Date of Election.

ORDINARY.

1856. Anderson, John, M.D., F.R.S., late Director of the Indian Museum, Calcutta, care of Messrs H. S. King & Co., 65 Cornhill, London.
1880. Anderson, James M., S.S.C., 1 Blackford Road.
1882. Andrew, George, S.S.C., 19 Magdala Crescent.
1884. Armitage, James Auriol, B.A.(Cantab.), 92 Lauriston Place.
1882. Armour, Henry, 115 George Street.
1884. Baildon, Henry B., B.A.(Cantab.), F.R.S.E., Duncliffe, Murrayfield.
1884. Baily, Edwin, M.B., C.M., Victoria Crescent, Oban.
1849. Barbour, G. F., F.R.S.E., of Bonskeid, 11 George Square.
1885. Barrett, W. H., M.B., C.M., 6 Lonsdale Terrace.
1880. Barron, H. J., M.B., C.M., 10 Endsleigh Street, Tavistock Square, London, W.C.
1884. Barrow, George, H.M. Geological Survey, George IV. Bridge.
1878. Beattie, William Hamilton, 68 George Street.
1884. Beaumont, Alfred, M.B., 30 Ladywell Park, Lewisham.
1880. Beddard, Frank E., M.A.(Oxon.), F.R.S.E., F.Z.S., Zoological Gardens, London.
1880. Begg, F. Faithful, 19 Learmonth Terrace.
1875. Bennie, James, Geological Survey Office, George IV. Bridge.
1881. Berry, William, of Tayfield, Newport, Fife.
1882. Bidwell, Edward, 1 Trig Lane, Upper Thames Street, London.
1880. Bird, George, 63 Haymarket Terrace.
1883. Black, Alex. M.B., C.M., M.R.C.P.E., 8 St Vincent Street.
1880. Bloxsom, William Gibson, 25 St Andrew Square.
1883. Bowie, A. F., 16 Duncan Street, Newington.
1885. Brooke, George, F.L.S., The University, Edinburgh.
1860. Brown, Robert, M.A., Ph.D., F.L.S., Fersley, Rydal Road, Streatham, London, S.W.
1884. Brown, James Kinniburgh, 35 St Andrew Square.
1876. Brown, J. A. Harvie-, F.R.S.E., F.Z.S. (*President*), Dunipace House, Larbert.
1885. Brown, J. Macdonald, M.B., F.R.C.S., F.R.S.E., 6 Atholl Place.
1876. Bruce, W. P., Kinleith Mill, Currie.
1883. Bryson, W. A., 20 Lomond Road, Trinity.
1885. Buckley, T. F., B.A., F.Z.S., etc., Torcastle, Fort William.
1878. Buchanan, J. Hamilton, 4 Doune Terrace.
1885. Burt, Robert F., M.B., C.M., Helsington, Knole Road, Bournemouth, E.
1882. Butler, Professor A. Stanley, M.A., University of St Andrews.
1881. Cadell, H. Moubray, B.Sc., etc., H.M. Geological Survey, and 12 Douglas Crescent.
1880. Caldwell, W. H., B.A.
1878. Cameron, John, S.S.C., 8 Castle Street.

Date of Election

1878. Campbell, R. Vary, Advocate, 37 Moray Place.
1880. Campbell, Walter, L.D.S., 27 Tay Street, Dundee.
1884. Campbell, Rev. John Kerr, Marykirk, Stirling.
1881. Capper, J. J., 1 Beaufort Road, Grange.
1877. Carmichael, Sir W. H. Gibson-, Bart., Castlecraig, Dolphinton.
1876. Carmichael, Thomas D. Gibson-, Castlecraig, Dolphinton.
1884. Carr, T F. Robertson, 20 Parade, Berwick-on Tweed.
1858. Carruthers, William, F.R.S., British Museum, London.
1880. Carter, W. A., M.I.C.E., 5 St Andrew Square.
Carter, J T., West Medical School, University Avenue, Glasgow.
1883. Chamberlayne, Edward.
1884. Chambers, Chas. E. S., 10 Claremont Crescent.
1881. Christie, William, Junior, Ardveich, Liberton.
1879. Coates, Henry, Pitcullen House, Perth.
1853. Cobbold, Spencer, M.D., F.R.S., 74 Portsdown Road, Maida Hill, London.
1881. Cook, Charles, W.S., 11 Great King Street.
1878. Cornillon, Hypolite W., S.S.C., 130 George Street.
1882. Cowan, Rev. W. Deans, Portobello.
1883. Cowper, John, 9 Merchiston Avenue.
1885. Cox, Ernest F., L.D.S., Jersey.
1881. Craig, Archibald, Jun., 16 Blacket Place.
1874. Crawford, W. C., Lockharton Gardens, Slateford
1882. Crockett, Samuel, Castle-Douglas.
1850. Crole, David, 1 Royal Circus.
1884 Cumming, W. J. H., 6 Barnton Terrace.
1884. Cunningham, J. T., B.A., F.R.S E., Fellow of Univ. Coll., Oxford, Scottish Marine Station, Granton.
1877. Dalgleish, John J., 8 Athole Crescent.
1879. Daniell, Alfred, M.A , D.Sc., F.R.S.E., 40 Gillespie Crescent.
1880. Denton, A., M.D., State Lunatic Asylum, Austin, Texas, United States.
1883. Dickson, G. W., M.B., C.M., M A., Dunkeld.
1876. Drinkwater, T. W., L.R.C.S.E., Laboratory, Chambers Street.
1880. Drummond, James, C.A., 27 Ann Street.
1880. Drummond, William, S.S.C., 4 Learmonth Terrace.
1883. Dunn, Malcolm, Dalkeith Palace Gardens.
1864. Duns, Rev. Professor, D D., F.R.S.E., 14 Greenhill Place.
1863. Edmonston, Alexander, Brentlands, Brookthorpe, Gloucester.
1880. Erskine, William, Oaklands, Trinity Road.
1877. Etheridge, Robert, Jun., F.G.S., British Museum, London.
1880. Evans, William, F.R.S.E., 2 Merchiston Bank Terrace.
1883. Ewart, Professor Cossar, M.D , F.R.C.S.E., F.R.S.E., Edinburgh University.
1884. Fenton, Gerald H., 17 Whitehall Place, London, S.W.
1884. Ferguson, James E. A., M.B., C.M., Castraes, St Lucia, West Indies.
1882. Ferguson, J., 18 Clyde Street.
1874. Ferguson, William, F.R.S.E., F L.S., F.G.S., of Kinmundy, 41 Manor Place.
1883. Finlayson, D., 1 Broughton Place.

Date of Election.

1883. Forbes, J. M., Bank of Scotland, Mound.
1883. Fraser, Charles, 13 Greenhill Place.
1877. Galletly, Alexander, Museum of Science and Art.
1880. Geddes, Patrick, F.R.S.E., 81A Princes Street.
1884. Geikie, Professor James, LL.D., F.R.SS.L. & E., University of Edinburgh.
1883. Gemmill, William, M.B., C.M., Drummore, by Stranraer.
1877. Gibb, Philip B., M.A., 14 Picardy Place.
1883. Gibson, E., 1 Eglinton Crescent.
1869. Gibson, John, (*Assistant Secretary*), 11 Melville Terrace.
1881. Gibson, John, Ph.D., F.R.S.E., University, and 20 Warrender Park Crescent.
1880. Glover, John, S.S.C., 1 Hill Street.
1881. Grant, Allan E., 15 Pall Mall, London.
1883. Grant, F. W., M.D., C.M., B.Sc., Barnard Castle, County Durham.
1878. Gray, Archibald, Bank of Scotland House, Bank Street.
1883. Gray, John, Pentland Oil Works, Loanhead.
1874. Gray, Robert, V.P.R.S.E., *Secretary*, Bank of Scotland House, Bank Street.
1878. Gray, J. Train, M.A., 16 Hope Terrace.
1884. Greg, Sydney Eustace, care of Mrs Ovens, 1 Clarendon Crescent.
1828. Grieve, David, F.R.S.E., 1 Lockharton Gardens, Slateford.
1877. Grieve, Somerville, Salisbury View, Dalkeith Road.
1884. Gunn, Henry H., A.R.S.M., Marionville Hall, near Edinburgh.
Hallen, J. H. B., 1 Lauriston Gardens.
1883. Hamilton, J. C., Trinity Lodge, Trinity.
1881. Hamilton, Robert, Trinity Lodge, Trinity.
1883. Hare, A. W., M.B., C.M., 21 Ainslie Place.
1882. Hay, Professor Matthew, M.D., University, Aberdeen.
1883. Henderson, J., Valley Farm, Kingsbury, Middlesex.
1883. Henderson, J. R., M.B., C.M., 1 George Square.
1883. Hepburn, D., M.B., C.M., Anatomy Department, Edinburgh University.
1871. Herbert, A. B., 13 Polwarth Terrace.
1879. Herdman, Professor W. A., D.Sc., F.R.S.E., F.L.S., University College, Liverpool.
1884. Hinxman, Lionel, H.M. Geological Survey, George IV. Bridge.
1882. Hird, T. A., Ford Street, Coventry.
1882. Hogg, Andrew, 94 George Street.
1858. Home, D. Milne-, LL.D., F.R.S.E., York Place.
1878. Horne, John, F.G.S., 41 Southside Road, Inverness.
1881. Horsley, R. E., M.B., C.M., 13 Great Stuart Street, and Kirkway House, Crail.
1884. Howell, Henry H., H.M. Geological Survey, George IV. Bridge.
1883. Hoyle, W. E., M.A.(Oxon.), M.R.C.S., F.R.S.E., 8 Kilmaurs Road.
1881. Humphrey, R., Holm Villa, Stanley Road, Trinity.
1880. Hunter, James, F.R.C.S.E., Craigmillar Villas.
1874. Hunter, John, F.C.S., Minto House, Chambers Street.
1878. Hunter, John, LL.D., Daleville, Braidwood, Lanarkshire.
1883. Jackson, J. E., High Green, Bridlington.

Date of Election

Jackson, Dr, Leith Fort.
1850. Jenner, Charles, F.R.S.E., Duddingston.
1877. Joass, C. Edward, 1 Rankeillor Street.
1884. Johnston, George, 2 Viewforth Place.
1880. Johnston, George H., 9 Claremont Crescent.
1880. Johnston, J. A., Haddington Place.
1881. Kemp, D. W., Ivy Lodge, Trinity.
1883. Kennedy, Charles, M.B., C.M., 8 St Andrew's Terrace.
1869. Kennedy, Rev. James, M.A., B.D., 36 Gillespie Crescent.
1878. Kidston, Robert, F.G.S., Victoria Place, Stirling.
Kilpatrick, H. Grainger, 18 Dick Place.
1869. King, J. Falconer, F. Inst. Chem., F.C.S., Minto House Medical School, Chambers Street.
1879. Kirke, D. J. B., Greenmount, Burntisland.
1880. Laughton, William, Mugie Moss Mill, Auchmill, near Aberdeen.
1881. Laurie, A. P., B.A.(Cantab.), B.Sc.(Edin.), F.R.S.E., Nairne Lodge, Duddingston.
1884. Laurie, Malcolm, Nairne Lodge, Duddingston.
1883. Lawson, G. R., Banker, Golspie.
1879. Leslie, George, M.B., C.M., F.R.S.E., Old Manse, Falkirk.
1883. Lindsay, D., M.B., C.M., Montreal House, Bothwell, Hamilton.
1884. Lindsay, Robert, Curator of Royal Botanic Garden.
1861. Logan, Alexander, Register House.
1850. Logan, R. F., Spylaw House, Colinton.
1881. Lumsden, J., of Arden, Alexandria, N.B.
1870. Lyon, F. W., M.D., 5 Duke Street.
1885. Macadam, W. Ivison, F.I.C., F.C.S., Surgeons' Hall.
1855. Macadam, Dr Stevenson, F.R.S.E., Surgeons' Hall.
1881. Macalpine, A. N., B.Sc., Minto House, Chambers Street
1882. Macdonald, W. R., 1 Forres Street.
1882. Macdonald, L. Mackinnon, Skaebost, Skye.
1885 MacGregor, John, L.R.C.P. & L.R.C.S.Ed., Lockwood, Huddersfield.
1879. Mackay, James S., per W. Gunn, 34 St Andrew Square.
1878. Mackay, James F., W.S., 81A Princes Street.
1885. Mackenzie, Wm. Cossar, 2 Grove Terrace.
1878. Maclaren, W. A., 51 Frederick Street.
1881. Maclaren, James, L.R.C.S.E., Asylum, Larbert.
1883. Maclaren, John, 25 Bread Street.
1878 Maclachlan, John, Albert Institute, Dundee.
1885. M'Naught, Rev. James, 31 Moray Place, Glasgow
1884. Macpherson, Rev. H. A., B.A.(Oxon.), 3 St James Road, Carlisle.
1882. MacVean, Colin Alexander, C.E., 42 Belmont Gardens, Hillhead, Glasgow.
1880. Marsden, R. Sydney, M.B., C.M., D.Sc., F.R.S.E. (*Librarian*), 17 Howard Place; and Rillington, near York.
1882. Mason, J. Gordon, S.S.C., 28 Howard Place.
1878. Matheson, Alexander, M.A., W.S., 19 Northumberland Street.
1881. Miller, Hugh, Assoc. R.S.M., F.G.S., Geological Survey Office, George IV. Bridge.

Date of Election.

1873. Miller, R. K., 4 Bonnington Terrace.
1883. Mitchell, Robert, 14 Marchhall Road.
1876. Moffat, Andrew, 28 Lutton Place.
1885. Monteith, James, 20 Cumberland Street.
1884. Morris, Rev. A. B., 18 Eildon Street.
1880. Muirhead, George, Paxton, Berwick-on-Tweed.
1881. Murdoch, T. Burn, M.B., C.M., 2 Greenhill Bank.
1882. Murdoch, James Barclay, Langside, Glasgow.
1877. Murray, John, Ph.D., V.P.R.S.E., 32 Queen Street.
1884. Murray, R. Milne, M.A., M.B., M.R.C.P.E., 10 Hope Street.
1874. Murray, D. R., M.B., C.M., 41 Albany Street, Leith.
1880. Nicholson, Professor H. A., M.D., D.Sc., Ph.D., F.L.S., F.Z.S., University of Aberdeen.
1883. Nichol, W. J., M.A., D.Sc., F.R.S.E., Mason College, Birmingham.
1883. Nicolet, Gustave Paul.
1884. Oliphant, John Christison, M.A., 50 Palmerston Place.
1858. Paterson, Robert, M.D., 32 Charlotte Street, Leith.
1870. Peach, Benjamin N., F.R.S.E., F.G.S. (*President*), 8 Annandale Street.
1867. Peach, Charles W., A.L.S., 30 Haddington Place.
1880. Pearcey, Fred., 32 Queen Street.
1884. Petty, Michael John, L.R.C.P. & S.E., Monte Video, and 16 Keir Street, Edinburgh.
1881. Pottage, John Cooper, 117 Princes Street.
1883. Prain, Henry, 29 Panmure Place.
1877. Prentice, Charles, C.A., F.R.S.E. (*Treasurer*), 40 Castle Street.
1883. Pullar, Alfred, M.D., 3 East Castle Road, Merchiston.
1879. Pullar, Rufus D., Tayside, Perth.
1885. Raeburn, Harold, 49 Manor Place.
1881. Ramsay, Captain Wardlaw, Whitehill, Rosewell.
1884. Rattray, John, M.A., B.Sc., F.R.S.E., Scottish Marine Station, Granton.
1882. Rawson, Herbert E., F.Z.S., 7 Cannon Street, London, S.E.
1868. Reid, Rev. J. Brown.
1883. Richardson, Lieut. R. M., 1st Seaforth Highlanders, 16 Coates Crescent.
1881. Richardson, Thomas, 29 Clarence Street.
1861. Robertson, Thomas, 21 Berners Street, London, W.
1883. Robertson, William W., H.M. Office of Works, Wardie Bank.
1882. Rogers, Rev. Charles, D.D., LL.D., 6 Barnton Terrace.
1880. Rowland, Professor L. L., F.R.S.E., University, Salem, Oregon, U.S.A.
1884. Scott, W. Sawers, M.B., C.M., 11 Albany Street.
1882. Seebohm, Henry, F.L.S., F.Z.S., 6 Tenterden Street, Hanover Square, London.
1880. Shaw, Duncan, 9 Heriot Row.
1884. Shaw, T., 41 St Andrew Square.
1883. Sheriff, George, Carronvale, Larbert.
1882. Simpson, James, Curator, Anatomical Museum, Edinburgh University.
1869. Skirving, Robert Scot-, 29 Drummond Place.

Date of Election.

1878. Smith, James D., 30 Buckingham Terrace.
1877. Smith, James A. J., M.D., Kimberley, South Africa.
1880. Sprague, T. Bond, M.A.(Cantab.), F.R.S.E., 29 Buckingham Terrace.
1880. Stark, Arthur Cowell, M.B., C.M., Eastbourne, Sussex.
1884. Stephen, Johnstone, Ravelston Cottage, Ravelston.
1882. Stewart, Robert, 21 Warriston Crescent.
1882. Stirling, James, of Garden, Stirlingshire.
1861. Struthers, James, M.D., 22 Charlotte Street, Leith.
1878. Surenne, David John, 6 Warriston Crescent.
1882. Swinburne, John, Eilan Shona, Salen, by Ardgour.
1879. Symington, Johnson, M.D., F.R.C.S.E., F.R.S.E., 10 Warrender Park Crescent.
1881. Tanner, Slingsby T., M.B., 67 Frederick Street.
1851. Taylor, Andrew, 37 South Clerk Street.
1882. Taylor, David, 7 Union Place.
1878. Thomson, Alexander, 35 Chester Street.
1876. Thomson, Andrew, 13 Inverleith Place.
1876. Thomson, John, 49 Great Ormond Street, London, W.C.
1878. Thomson, Mitchell, 7 Carlton Terrace.
1874. Thomson, Robert, LL.B., 6 Shandwick Place.
1881. Todd, W. Lang, Advocate, 16 Great Stuart Street.
1859. Traquair, R. H., M.D., F.R.SS.L. & E., Museum of Science and Art.
1885. Turnbull, Percy Y., 28 Scotland Street.
1858. Turner, Professor William, M.B., LL.D., F.R.SS.L. & E., F.R.C.S.E., Edinburgh University.
1862. Waddel, Peter, Claremont Park, Leith.
1874. Walcot, John, 50 Northumberland Street.
1882. Wallace, Professor Robert, Edinburgh University.
1884. Watson, William, M.D., Northfield, Liberton.
1884. Watson, C. Heron, Mall Park, Musselburgh.
1878. Watson, George W., 3 Walker Street.
1884. Webster, A. D., M.D., F.R.C.P.E., 10 West Newington Terrace.
1881. White, John, 22 Manor Place.
1878. White, Thomas, S.S.C., 114 George Street.
1884. White, J. Martin, yr. of Balruderry, Springrove, Dundee.
1884. Wight, Laurence Hill, M.A., 41 Chambers Street.
1885. Williams, W. Owen, M.R.C.V.S., New Veterinary College, Edinburgh.
1856. Wilson, Andrew, L.D.S., 21 Young Street.
1885. Wilson, Alfred C., 75 High Street, Stockton-on-Tees.
1882. Wilson, J. S. G., Geological Survey Office, George IV. Bridge.
1883. Wilson, T. D., M.A., M.B., C.M., West Newington House.
1883. Woodhead, G. S., M.D., F.R.C.P.E., 6 Marchhall Crescent.
1882. Woods, W. C., M.B., C.M., Albury, New South Wales, Australia.
1881. Young, F. W., F.R.S.E., F.C.S., High School, Dundee.
1882. Young, J., 64 Hereford Road, Bayswater.
1884. Young, Robert, Uphall Oil Works.
1885. Younan, Arthur C., M.B., C.M., Indian Medical Service, Calcutta.
1885. Zepero, J. Henry, L.R.C.P., L.R.C.S.Edin., Port of Spain, Trinidad.

NON-RESIDENT.

Date of Election.

1864. Belairs, George, Caroline Lodge, Duddingston.
1862. Bethune, Norman, M.D., Toronto, Canada.
1872. Brown, D. J., Glasgow.
1862. Brown, J. Crichton, M.D., F.R.S., London.
1867. Brown, Geo. H. Wilson, Vancouver Island, British Columbia.
1862. Cæsar, Rev. W., D.D., Tranent.
1861. Cameron, A. G. H., Lakefield, Inverness.
1840. Cleghorn, Hugh, M.D., F.R.S.E., F.L.S., Stravithie, Fife.
1873. Dally, Frederick, M.D., Wolverhampton.
1864. Davidson, Andrew, M.D., Madagascar.
1868. Davies, A. E., Ph.D., F.C.S., Lowes Moor, Worcester.
1870. Dick, Thomas, Kirknewton.
1858. Drummond, Captain H., India.
1863. Fair, George, M.D., Buenos Ayres.
1863. Galbraith, George L., Loch Tummel Lodge, Pitlochrie.
1859. Grierson, T. B., L.R.C.S.E., Thornhill.
1855. Hector, James, M.D., C.M.G., F.R.S., New Zealand.
1851. Heddle, Professor M. Forster, M.D., F.R.S.E., St Andrews.
1849. Hepburn, Archibald, Barwood House, Ramsbottom.
1874. Hitchman, William, M.D., 29 Erskine Street, Liverpool.
1862. Hargitt, Edward, London.
1872. Hoggan, George, M.D., London.
1861. Home, Lieutenant-Colonel George Logan, Edrom, Duns.
1860. Hunter, Rev. Robert, Library of the Royal Historical Society, London.
1867. Kennedy, John, M.D., Elie.
1850. Lawson, Professor George, LL.D., Windsor, Nova Scotia.
1861. Logan, Robert, Carluke.
1862. Macnab, Professor W., M.D., F.L.S., F.R.S.E., Royal College of Science, Dublin.
1862. Manson, George W., Bengal Staff Corps.
1849. Melville, Professor A. G., Queen's College, Galway.
1870. Middleton, James, M.D., Strathpeffer.
1871. Paterson, J., M.D., Brazil.
1878. Prentice, Norman, Otago, New Zealand.
1862. Roome, Major Frederick, Bombay.
1856. Sanderson, Professor R. Burdon, M.D., LL.D., F.R.S., Physiological Laboratory, Oxford.
1857. Shields, Robert, Kentish Town, London.
1861. Struthers, Rev. John, Prestonpans.
Swift, Herbert M., Whitehall, London.
1861. Thomson, Professor Murray, M.D., Calcutta.
1860. Valentine, Colin S., LL.D., Jeypore.
1861. Wanklyn, Professor J. A., M.R.C.S., F.R.S., F.C.S., etc., London.
1870. Wilson, Robert, *Standard*, London.
1874. Young, David.